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The Biology of the North American Crane-Flies

(Tipulidae, Diptera)

VI. The Genus Cladura Osten Sacken

By Charles P. Alexander

Generic Diagnosis

Larva. Form comparatively short and stout; integument provided with a delicate appressed pubescence; no distinct setae; basal annulus of each of abdominal segments two to seven with a transverse area of microscopic points arranged in long, transverse rows. Last ventral segment with a flattened lobe covered with short setae, evidently an organ for shoving. Spiracular disk entirely without lobes, the spiracles being situated on the exposed dorso-caudal surface of the last abdominal segment. Head-capsule relatively compact; frontal plate broad, only slightly narrowed behind. Labrum quadrate, with conspicuous, oval, lateral arms; antennae two-segmented, the terminal segment elongate-oval; mandibles of a herbivorous type, with an apical point and two incomplete rows of teeth on the inner or cutting face; mental bars widely separated, each bar provided with two acute teeth at its mesal end.

Pupa. Cephalic crest gibbous, entire or feebly bifid, armed on either side with a single powerful bristle; two bristles on both the front and vertex; labrum with pair of small bristles at each cephalic-lateral angle; labial lobes subquadrate, weakly separated by the apex of the labral sheath; palpal sheaths short and stout, straight; lateral margins of eye produced laterad into a digitiform lobe; antennal sheaths extending to opposite one-third the wing-sheaths. Pronotal breathing horns lacking, entirely sessile; pronotum and mesonotum armed with conspicuous bristles; wing-sheaths ending opposite the base of the third abdominal segment; leg-sheaths long, ending opposite the base of the sixth abdominal segment, the hind legs longest, the middle legs shortest. Abdominal tergites with ten strong bristles, eight being arranged in a single transverse row along the posterior margin; abdominal pleurites with four strong bristles, one on anterior ring, two near the caudal margin of the posterior ring, one ventrad of the spiracle; spiracles rudimentary, situated on segments two to seven; sternites unarmed with bristles.

Discussion of the Genus

The genus *Cladura* was erected by Osten Sacken in 1859 (Proc. Acad. Nat. Sci. Phila., p. 229). The genus includes but six

known species, with a Holarctic distribution, there being two species from eastern North America, one from western North America, and three from Japan. Of the eastern North American species, the most common and best-known is the genotype, *Cladura flavoferruginea.* The six known species of the genus are all forms that appear on the wing in late summer and in autumn.

The only reference to the immature stages of this curious genus is the brief diagnosis by the writer (The Crane-flies of New York, Part II. Biology and Phylogeny. Cornell University Agricultural Experiment Station, Memoir 38, p. 949; 1921). The genotype is common and widely distributed throughout the northeastern United States, but until the present year the writer had been unable to locate the immature stages. The conditions under which these stages occur are briefly outlined herein.

Augurville, or Brownsfield, Woods, near Urbana, Illinois, is an open, low Transitional or upper Austral woodland, traversed in spring and early summer by a small stream. In early spring the valley through which this brook flows is carpeted with a dense growth of Blue-eyed Mary (*Collinsia verna*). On the higher ground and dry slopes, other characteristic spring flowers, such as *Trillium recurvatum, Claytonia virginica,* squirrel-corn, dutchman's breeches, blood-root, white trout-lily, and other forms, occur in numbers. The forest cover consists of linden, hard maple, buckeye, hackberry, bur oak, honey-locust, and a few less common species, certain individuals of all of these species being giants of their kind and evidently members of the primitive forest. The undergrowth consists principally of pawpaw and spice-bush, together with considerable reproduction of buckeyes and other trees. In the autumn, the vernal flora is replaced by the dominant wood-nettle, many species of *Aster* and *Solidago,* some *Eupatorium* and other late summer plants. Adults of *Cladura flavoferruginea* were found in these woods during the fall of 1919.

On September 5, 1920, Mrs. Alexander and the writer began a systematic search for the larvae of *Cladura.* Earlier experience in Maine, New York, and Kansas had demonstrated that it was highly improbable that the early stages were to be found in mud, or even in damp earth, or in decaying wood, these habitats being those commonly frequented by the early stages of the Tipulidae. A careful search was instituted in soil that was baked comparatively hard and dry. The lumps were dug out and crumbled into dust, the contents being carefully examined. This method of search soon revealed a short, stout, light yellow crane-fly larva, that was at once determined as probably being that of *Cladura.* On this date, the only other insects associated with this larva were larvae of the Scarabaeid, *Xyloryctes satyrus* (Fabr.), a Tenebrionid, *Meracantha contracta* (Beauv.), and a few adult Corabidae and Staphy-

linidae. The conspicuous millepede *Spirobolus marginatus* (Say), was also found in these situations. The soil was covered with a layer of dead leaves and other vegetable detritus, but this had not been sufficient to prevent the dessication of the soil to a depth varying from six to twelve inches or more. Three larvae taken on September 5 were placed in breeding vials.

On September 19, 1920, Mrs. Alexander and the writer continued the search in these same haunts, and this resulted in the discovery of six additional larvae and four teneral pupae. As before, they occurred in soil that was very dry, underneath a layer of leaf-mold and other debris. These were placed in rearing.

On September 29, 1920 the writer again went to Augurville Woods. The weather was very cold and raw. By careful searching, eight pupae were discovered, some being very dark colored and evidently nearly ready to transform to the adult condition. These were placed in tin salve boxes for rearing. On the following day, two females of *Cladura flavoferruginea* emerged from two of the pupae discussed above. Other adults emerged during the following week. The remaining larvae and pupae were preserved in alcohol.

Bergroth and other writers had surmised the relationship of *Cladura* to the nearly apterous snow-fly, *Chionea* Dalman, a fact that is amply substantiated by the discovery of the larvae of the two genera. Brauer, Egger and Frauenfeld (1854) had taken gravid females of the commonest European species of *Chionea, C. araneoides,* and confined them in breeding jars, where they laid a large number of eggs, which hatched into stout yellow larvae that agree in many features of their organization with the larvae of *Cladura* described in this paper. Unfortunately the larvae of *Chionea* have never been carried through to the pupal condition.

The larvae of the two genera agree in their short, stout form, the obliquely truncated spiracular disk that is quite devoid of surrounding lobes, and in the general features of the head capsule. The pupa of *Cladura* is notable by the entire lack of protuberant breathing-horns, the breathing-pores being entirely sessile. The nearest approach to this condition in the Tipulidae is found in the genus *Dicranoptycha* Osten Sacken, which is likewise characteristic of unusually dry conditions in open upland woods. Other notable features of the pupa of *Cladura* are found in the very elongate leg-sheaths and the unusual development of long setae on the dorsal and pleural regions of the abdomen. The pupa is very small compared with the adult which emerges from it.

Natural Affinities

The genus *Cladura* unquestionably belongs to the tribe Eriopterini where it was placed by Osten Sacken. The discovery of the immature stages confirms the belief that this genus, as well as *Chionea* Dalman, and probably *Crypteria* Bergroth and *Ptero-*

chionea Alexander, should be isolated from the Eriopteraria where now placed and made a separate subtribe, the Chionearia or Claduraria, the former name being based on the oldest genus.

DESCRIPTION OF THE IMMATURE STAGES

Larva—Length (fully grown), 10-10.5 mm.

Diameter, 1.2 mm.

General coloration light yellow throughout.

Form comparatively short and stout. Integument provided with a delicate appressed pubescence; no distinct setae. Abdominal segments divided into a narrow basal annulus and a much broader posterior annulus, the latter being approximately two and one-half times as long as the former; the ventral surface of the basal annuli of abdominal segments two to seven with a conspicuous transverse area of microscopic points arranged in long transverse rows.

Spiracular disk entirely destitute of lobes, the spiracles being located on the obliquely truncated dorso-caudal surface of the last abdominal segment. Spiracles circular, the ring pale, the centers dark; spiracles separated from one another by a distance about equal to or a little less than the diameter of one. Ventral surface of the terminal abdominal segment with a projecting, flattened lobe that is provided with a dense brush of short, pale setae, this organ presumably being used for propelling the insect through the soil.

Head entirely retractile. Head-capsule very compact for a member of the Eriopterini. Frontal plate broad, only slightly narrowed behind, the apex obtuse or subtruncate. Labrum-epipharynx quadrate, the surface covered with short, dense hairs; on either side a stout oval arm or lobe directed cephalad, these arms connected by narrow bars, with the frame-work of the head. Mental bars entirely separate, each bar with two acute teeth on the cephalic side immediately before the apex. Antennae two-segmented, the basal segment short-cylindrical, the terminal segment elongate-oval, gradually narrowed to the obtuse apex. Mandibles relatively slender, of a herbivorus type, the teeth blunt; apical point small; two incomplete rows of flattened obtuse denticles along the inner face of the mandible, the outermost tooth of each row largest, the others gradually smaller, becoming subobsolescent; the basal teeth are very tiny, arranged in short combs; proximal caudal angle of the mandible produced into a cylindrical chitinized bar. Maxillae consisting of simple hairy lobes.

Pupa—Length, 6.7 mm.

Width, d.-s., 1.4 mm.

Depth, d.-v., 1.4 mm.

The coloration of newly transformed pupae is pale yellow. In older individuals, the thorax, head and sheaths of the appendages gradually deepen in intensity to almost black in specimens about to transform.

Cephalic crest projecting between the antennal bases as a gibbous lobe that is entire or microscopically bifid, on either side with a conspicuous erect bristle situated immediately dorsad of the base of the antenna. Vertex between the cephalic ends of the eyes with a strong bristle on either side, immediately caudad of each of which is a small tubercle. Frontal region likewise with a pair of strong bristles that are somewhat appressed against the face, directed caudad. Labral sheath with the apex rounded, very narrowly separating the labial lobes; at the base of the labrum on either side are two small bristles; sheaths of the palpi short but stout. Lateral margin of the eyes produced laterad and slightly caudad and dorsad into a conspicuous finger-like lobe. Antennal sheaths extending to about opposite one-third the length of the wing-sheath.

Pronotal breathing horns entirely lacking, the pores being sessile, lying immediately dorsad of the antennal sheaths. Pronotal scutum with two weak bristles behind the antennal sheaths; pronotal scutellum with three powerful bristles on either side near the summit. Mesonotum gibbous but unarmed with tubercles or spines. The following mesonotal bristles are evident: one on the ventral caudal angle immediately cephalad of the wing-root; a group of two, one being much smaller than the other, immediately at the wing-root; a transverse row of three strong bristles on either side, dorsad and proximad of the wing-root; two weak bristles slightly cephalad of the level of these latter three, one on either side of the median line; a strong bristle dorsad and cephalad of the pair at the wing-root. Metanotum with a strong bristle at the ventral cephalic angle. Wing-sheaths extending to opposite the base of the third abdominal segment. Leg-sheaths long, extending to opposite the base of the sixth abdominal segment; sheaths of the posterior legs longest, a little exceeding those of the fore-legs; middle legs shortest, ending immediately beyond the base of the last segment of the posterior sheaths.

Abdominal tergites and pleurites with very conspicuous bristles; sternites entirely unarmed. The distribution of the setae is as follows: On the tergites—no setae on the anterior annulus; on the posterior annulus a single transverse row of eight long bristles along the posterior margin of the segments, four on either side of the median line; cephalad of the outermost pair of these bristles and located on the anterior part of the posterior annulus is a single strong bristle on either side; on the eighth tergite there are only four bristles, arranged to form a rectangular or trapezoidal figure. On the pleurites,—each pleurite bears four very powerful bristles, one opposite the anterior annulus, one immediately ventrad of the

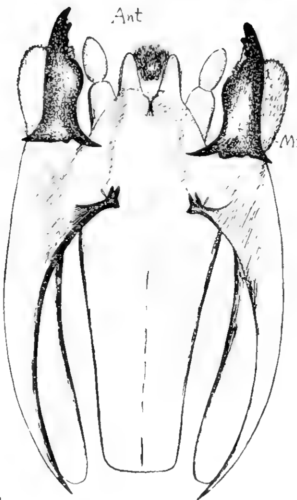
rudimentary spiracle, the remaining two in a transverse row on the posterior ring near the caudal margin; on the eighth pleurite there is a single bristle. On the sternites, no bristles. Terebra of the ovipositor ending almost on a common level, the tergal valves a very little longer; each tergal valve terminates in four rather weak bristles. In the male pupae, the sternal valves are slightly more tumid and project beyond the level of the tergal valves.

Nepionotype. Urbana, Illinois, September 19, 1920.
Neanotype. Urbana, Illinois, September 29, 1920.
Paratypes, larvae and pupae, September 5, 19, 29, 1920.

EXPLANATION OF PLATE

Fig. 1. Head capsule of larva, ventral aspect.
Fig. 2. Mandible
Fig. 3. Apex of mental bar.
Fig. 4. Antenna of larva.
Fig. 5. Spiracular disk of larva, dorsal aspect.
Fig. 6. Spiracular disk of larva, lateral aspect.
Fig. 7. Pupa, lateral aspect.
Fig. 8. Head of pupa, ventral aspect.

Ant.=Antenna; Lb.=Labium; Mx.=Maxilla; P.= Maxillary sheaths.



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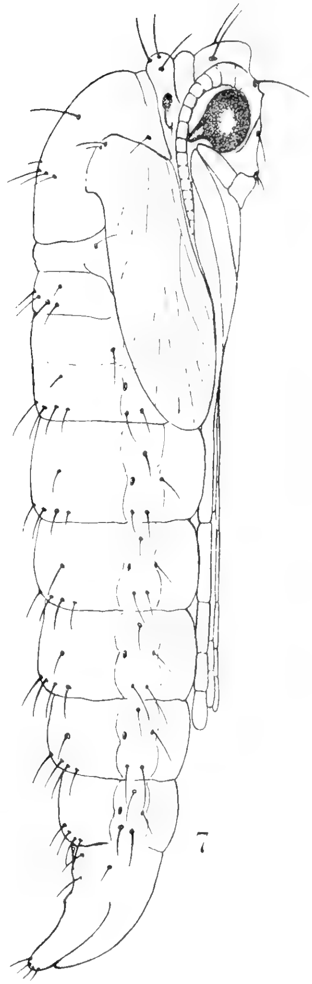

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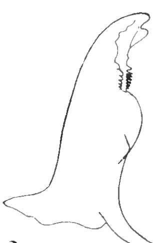

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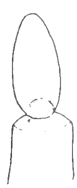

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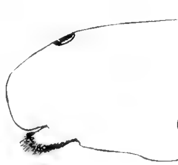

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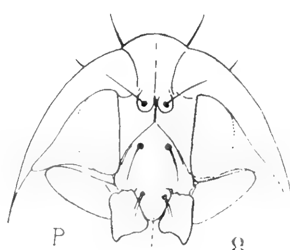


8

A New Platydesmoid Diplopod from California

By Ralph V. Chamberlin

From Dr. Hilton I have received an adult and several immature specimens of the interesting new genus below described. The male is not yet known.

Gosodesmus, gen. nov.

A genus differing from Platydesmus and Brachycybe in its much narrower keels, the body as a whole being slender, more as in Dolistenus and Pseudodesmus, body differing from that of the last mentioned genus in being much more depressed, the keels horizontal or, on anterior segments, upturned. Keels for the most part laterally a little thickened or margined. Dorsum of each segment with two transverse rows of large tubercles which are laterally compressed, in part cariniform, the median ones not greatly enlarged as in Pseudodesmus, pores not pedicillate; opening at margin. Fifth segment normal. Head as in Brachycybe; no eyes present.

Genotype.—*G. claremontus*, sp. nov.

Gosodesmus claremontus, sp. nov.

The dorsum of the type is fulvus, in part of a distinct reddish or pink tinge. The venter paler.

Head shaped nearly as in *Brachcybe lecontii* but somewhat narrower and the antennae a little more clavate.

Keels of first five segments bent forwards, laterally strongly rounded. Keels of sixth and seventh segments also bent forwards but with the lateral margins straight at middle, the corners, however, widely rounded. On subsequent segments the keels have the posterior corners extended a little caudad, the production becoming pronounced in the caudal region. Keels of the penult segment produced directly caudad, nearly as far as caudal margin of last tergite. Lateral margins of keels caudad of the eighth with straight portion longer, slightly indented at middle, margined. The angles on all keels remain rounded, but the posterior ones in the more caudal segments narrowly so. Caudal margin of keels toward mesal or proximal end bulging or shouldered, the caudally extending portion abutting against or a little overlapping the anterior border of the succeeding keel. First tergite with six tubercles in each row, or with one or two extra ones in an indistinct third row along anterior border. Tergites of middle region of

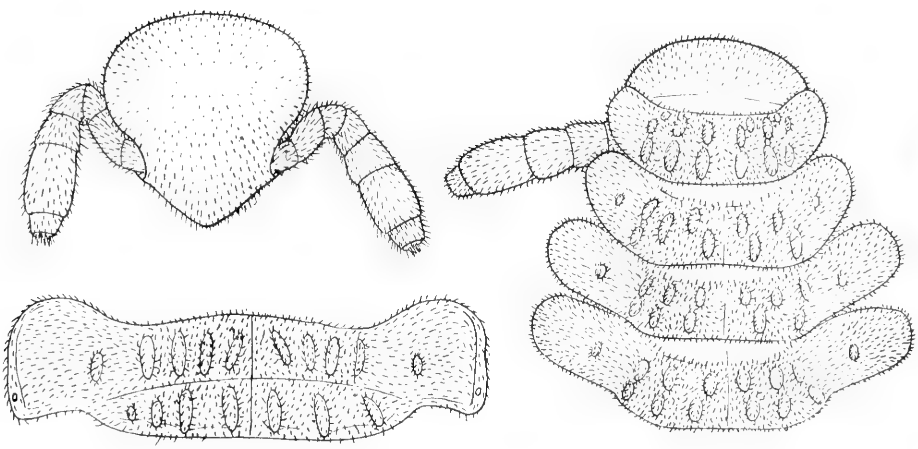
body with mostly ten tubercles in the anterior row, and six or eight in the posterior one.

Anal tergute broad, sides straight, caudal margin gently convex.

Number of segments in type (female), fifty-two.

Length, 13 mm.; width, 1.2-mm.

Locality.—California: Claremont.



Gosodesmus claremontus, sp. nov. Anterior view of head to left above, below dorsal view of seventeenth tergite. On the right, dorsal view of head and first four tergites, with right antenna omitted. x55.

Hydroids Near Laguna Beach

Arthur S. Campbell

The hydroid fauna of Laguna Beach has been little studied but there are a number of interesting forms to be found there. A few collections, made almost at random from time to time, and with no special search, form the basis of these notes.

The excellent papers by Torrey, Calkins, and Nutting have been freely consulted in making the determinations. The splendid monograph by C. C. Nutting is especially invaluable to all who may have to do with a systematic discussion of the group.

The more valuable results of this short paper are the distributional and systematic records, together with notes concerning ecological and breeding relations. More extensive studies will reveal much data not hitherto brought to light concerning the ecology, life-histories, variations, and other bionomical details of the group in this interesting locality.

Key to the Hydroids of Laguna Beach

A. Hydranth without hydrotheca.

- B. Hydranth with a basal whorl of filiform tentacles.
  - C. Hydranths solitary. Large. *Corymorpha palma.*
  - CC. Hydranths colonial.
    - D. Branched profusely. Medium size, often pinkish in color. *Tubularia crocea.*
    - DD. Branched sparsely. *Tubularia sp.*
- BB. Hydranth with distal, knobbed tentacles. *Syncoryne mirabilis.*

AA. Hydranth with hydrotheca.

- B. Hydrotheca sessile. Gonangia are sporosacs.
  - C. Hydrotheca in two rows, usually opposite, on the stem.
    - D. Hydrotheca margin with two teeth. *Sertularia furcata.*
    - DD. Hydrotheca margin smooth, tubular, adnate at base. *Sertularia tricuspidata.*

CC. Hydrotheca in a single row on stem.

D. Hydrocladia on erect stems.

E. One or more intermediate internodes. Hydrotheca as deep as long.
Plumularia setacea.

EE. Septal ridges moderate, usually two in each internode.
Plumularia lagenifera.

DD. Hydrocladia modified as corbulae protecting gonotheca.

E. Median tooth straight. Nine teeth.
Aglaophenia pluma

EE. Eleven teeth, irregular.
Aglaophenia struthionides

BB. Hydrotheca stalked, bell-shaped.

C. Gonophores are sporosacs.

CC. Gonophores are medusae.
Campanularia exigua.

D. Pedicels in pairs.
Obelia gracilis.

DD. Pedicels not in pairs.

E. Pedicels on shoulders produced from stem.
Obelia geniculata.

EE. Pedicels not geniculated, branching on all sides.
Obelia commissuralis.

Sertularia desmoides Torrey and *Eudendrium ramosum* L. obtained during the summer of 1921 are not included in this key. They were determined for us by Mr. W. S. Wallace of the Hopkins Marine Station, Pacific Grove, Calif.

TUBULARIAE

CORYNIDAE: No basal whorl of tentacles, but with tentacles scattered irregularly over the hydranth. Tentacles knobbed. Hydroid branched.

Syncoryne mirabilis (Ag.) Torrey. U. C. pub. Zool. Vol. 1. 1902. p. 31.

Hydranth cylindrical. Proboscis conical. Scattering, capitate tentacles. Small. Bathymetrical range; exposed to breakers of open sea or in quiet harbours, ours on exposed pier with *O. com-*

missuralis, on live *Mytilus*. Abundant. With medusae in December, 1920.

CORYMORPHIDAE: Large, solitary hydranth with basal and distal whorls of filiform tentacles. Medusae produced just within basal tentacles.

Corymorpha palma Torrey. Hyd. Pacific Coast. U. C. pub. Zool. vol. 1, no. 1, p. 37.

A very large and beautiful species found abundantly in quiet pools. Solitary, rooted in sand by filamentous processes. Proximal tentacles 18-30 in number. Balboa Bay, in sandy pool. Usually numerous in unexposed places.

TUBULARIIDAE: Solitary or colonial. Large, often bright pink in color. Hydranths with a basal and a distal whorl of filiform tentacles. Sporosacs are pendant clusters.

Tubularia crocea (Ag.) Allman. Gym. Hyds. 1871. Dense colonies, 8-10 cms. in length. Few branches. About 20-24 basal tentacles. On piles with other hydroids, tunicates, crustacea and mollusca. Low tide, December, 1920. Long Beach, Cal.

Tubularia sp. Distinguishable from above species in several characters but not corresponding with any available discriptions. I am not inclined to think it the *T. marina* of Torrey. Growing with the above species at Long Beach. Rather rare. Probably the same species discussed by Professor Bean in the Fourth Laguna Report of Pomona College. Specimens also collected during the summer of 1921.

SERTULARIIDAE: Colony usually branching; hydrothecae sessile, forming a double row along opposite sides of hydrocaulus; gonangia large, few, no free medusae.

Sertularia furcata Trask. Proc. Calif. Acad. Sc., 1854, I, p. 112.

This is a very variable species but ours are typical and agree with figured specimens of several authors. Gonangia were numerous on colonies taken at Huntington Beach, April, 1921, from piles under the pier. Numerous, on stalks of algae and on rope.

Sertularia tricuspidata Hincks. Hist. Brit. Zoophytes. London, 1868.

This is a very common species at Laguna Beach, growing in great numbers on *Fucus* with other hydroids. Inshore tide zone. January, 1921. With a creeping rootstock on which there are a few gonangia, ripe. Hilton.

Campanulariae

Plumulariidae: Hydranths sessile, borne in a row on small lateral branches, with nematophores. Gonangia large.

Plumularia setacea (Ellis) Lamark. Anim. sans Vert., 1st ed. 1815. p. 129. Large. Nematophores, 2 above and one below hydranth. Alternate hydrocladia. Not branched.

On piles under the Pleasure Pier, Long Beach, Calif. Low tide, December 1920. Gonangia ripe, in pairs.

Plumularia lagenifera Allman. Jour. Linn. Soc. Lond., 1885, XXIX, p. 157, pl. XXVI. Very large and stiff. Unbranched. Corbula not numerous. Station unknown, probably from dredgings at Laguna Beach by Bean.

Aglaophenia struthionides (Murry) Clark. Trans. Conn. Acad., III, 1876, p. 272. Small, abundant on *Fucus* inshore, at Laguna Beach. With ripe gonangia January, 1921. Hilton. Commonest hydroid.

Aglaophenia pluma (Linn.) Lamx., Hist. Pol. Flex. 1816.

Some very typical specimens of this species were taken from near the end of the pier at Huntington Beach, California. Readily distinguishable by striking contrast in color of dark stem and lighter hydrocladia. Rather tall. With corbulae in April, 1921.

Eucopidae: Colonial, either branched or simple; hydrothecae campanulate, stalked; aperture toothed or not; gonangium large usually in axil of branch, free medusae.

Obelia commissuralis McCr. Gym. Charls. Harb., p. 95.

High, sparsely branched colonies. Hydranth deeply campanulate. Pedicels annulate throughout, alternate.

On live *Mytilus* with other hydroids. Long Beach Pier, not rare. December, 1920.

Obelia geniculata (Linn.) Schulze. Nordsee Exped. 1872. p. 129.

An abundant shore form everywhere. On *Fucus* inshore. Laguna Beach, Calif. January, 1921. No gonangia.

Obelia gracilis Calkins. Some Hydroids of Puget Sound, 1899, p. 353.

Some typical specimens were taken on stems of other hydroids from pier at Huntington Beach, California. No gonangia in April, 1921.

CAMPANULARIIDAE: Either a branched or a simple colony on which are campanulate and usually stalked hydrothecae; hypostome trumpet-shaped. Gonangium large, never with free medusae.

Campanularia exigua (Sars) Van Beneden. Rec. sur la Faune Littorale de Belgique. 1867, p. 163.

This species I am not at all certain about but my specimens seem to agree very well with descriptions and keys of both Nutting and Torrey. If the identification should prove correct the species has a much more southerly distribution than hitherto reported. Calkins reports it from Puget Sound but Torrey has not included it in his descriptions. The species is decidedly northern.

The gonangia of my specimens are a little fuller and with more pronounced opercula than that figured by Nutting, but as those of my specimens are ripe and those figured by Nutting are not this may be of little significance.

Specimens on thalli of a seaweed, probably *Macrocystis*, exact source unknown. Bottle labeled. Illingsworth, Pacific Grove, July, 1899. Many ripe gonangia.

(Contribution from the Laguna Marine Laboratory of Pomona College.)

VIII.

Rotifera, Gastrotricha and Kinorhyncha

ROTIFERS. The usual type of nervous system of the female is a dorsal ganglion or brain from which slender nerves pass to tentacles, the ciliary disc or the general body. In *Discopus*, Zelinka shows a ventral oesophageal ganglion as well as the usual dorsal one. The shape of the brain or dorsal ganglion differs somewhat in various species being almost spherical in some and quite elongate in others, and in many cases bi-lobed. In *Frullaria* several longitudinal strands of the nervous system have been shown. At nodal points ganglion cells are located. The peripheral nerves are chiefly as follows: one to each of the tentacles; a pair of lateral nerves which descend into the body and divide into two main branches, one more ventral and one lateral, which give off numerous lateral divisions to the muscles and viscera. Many fine branches run from the brain to the ciliary ring to end in intimate relation with the ciliary cells.

Antennae or feelers, usually three in number, a median dorsal and two lateral ones are supplied by definite nerves. Each of these structures consists of a small cluster of sense hairs born on a slight swelling which receives the nerve. Sometimes the antennae are retractile by means of internal muscle. These antennae may be organs for touch or smell or both.

The brains of some forms contain a sac full of mineral material. This may be some sort of sense organ, possibly a statocyst.

The eye-spot in its simplest form is a refractive globule in a red pigmented cup to which latter nerve fibers pass, or the eye or eyes may rest directly on the brain. Sometimes two eyes occur and these may be very close together, almost like one. In some species the eyes are just under the ciliary band or within the disc. A median and two lateral eyes occur in some forms, or even another pair of eyes may also be found. In some, pigment spots occur at the hind end of the body.

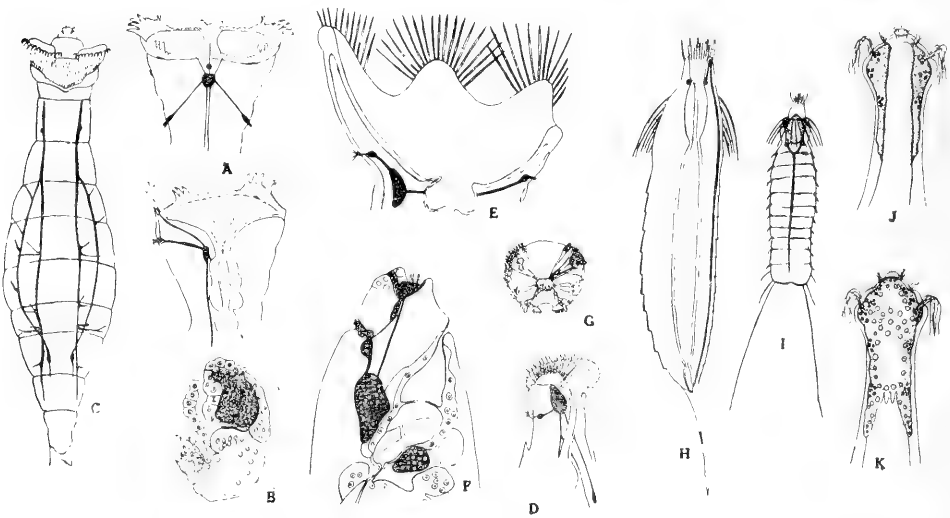
It has been suggested that some rotifers are able to avoid objects by means of a sense of sight aided by the tactile and olfactory sense.

The chief work on the nervous system of this group has been by Zelinka, 1888-90, Gast, 1900, and Halva, 1905. The more recent work of Hirschfelder, 1910, has added quite a little to our knowledge of the nervous system and sense organs in a number of forms. This last author recognizes four general types of nerve cells which grade into each other to some degree. Nerve fibers are described as containing a central core of fibrils, an intermediate covering and an outer sheath. Cells are uni- or bi-polar; the last kind has one

process passing to the periphery, the other running centrally. The number, position, size and form of the cells is symmetrical in both halves of the ganglion, also the processes are symmetrically disposed. Commissural fibers bind right and left halves of the ganglion. Some fibers leave the brain directly from ganglion cells while others enter or leave by way of paired nerve fibers which connect directly with the central fibrous core of the ganglion.

The ganglion cells are said to be absolutely constant as to their position, form and relative size. The position of the nuclei in the cytoplasm is not so constant. The larger and smaller fibers seem also constant in number and position.

Sense cells are found at the surface of the body more or less removed from the surface. Single sensory nerve cells with two nuclei end directly in the surface. Another kind of sensory ending



A. *Rhizotida*, front and profile, showing position of the nervous system. Zelinka.

B. Embryonic stage of a rotifer showing position of nervous system in two dark masses. Zelinka.

C. *Frullaria*, showing position of nerve strands in the body.

D. Position of nervous system in rotifer after Delage et Herouard.

E. Nervous system of *Floscularia* after Hudson and Gosse.

F. *Discopus*, showing nervous system, after Zelinka.

G. Sense organs with nerves from the brain shown in cross section after D. & H.

H. Nervous system of *Echinoderes* from several sources.

I. Nervous system of *Echinoderes* from above. Schepotieff, but much changed.

J. K. Head end of *Chaetonotus* from below J. and above K. showing brain and sense hairs. Zelinka.

is found in the tentacles where there is a combination of sensory cells at the base of the sense organ.

The retrocerebral apparatus in *Eosphora* consists of two glands lying back of the brain. They are covered with membrane and so not in direct connection with the brain. One of these glands is the pear-shaped retrocerebral sac which is clear with vacuoles. If this is in any way a sense organ it is a question what its function would be.

In *Eosphora* there is a single eye on the surface of the brain and two slightly pigmented knobs at the anterior margin of the animal; these have a direct connection with the brain and must be sense organs, possibly something like eye spots.

GASTROTRICHA. In 1864 Gosse described a knob on the oesophagus as the brain in *Chaetonotus*. Ludwig in 1875 described the nervous system on the side of the brain. Butschli, 1876, added nothing of importance and Fernald, 1890, did not see the brain in *Chaetonotus*. The clearest recognition of the nervous system was by Zelinka in 1890. A large brain in the head region surrounds the gullet above and on the sides and a pair of nerve trunks extend down the body. Cephalic sense hairs are directly connected with nerve cells of the brain. The hairs of the body may be for touch or possibly smell or taste. Simple eyes have been described for a number of species in the back part of the head, as small red spots, but not all species possess them.

KINORHYNCHA. Claparede in 1863 describes a nervous system in this group and others at an early time also figure or describe something of the nervous system. Reinhard, 1887, believes that in most cases the nervous system was not seen by the earlier investigators. He describes and figures a ganglion on the oesophagus but gives no details. Zelinka, 1894, describes a circum-oral ring and a long ventral nerve strand. Schepotieff, 1907, describes a brain above the oesophagus with two connectives and a ventral strand. The nervous system is somewhat like that of Gastrotrichia with a large upper brain of a large mass of three general parts all fused. The ventral strand runs the length of the body but is not differentiated into ganglia but has cells along its course. Eye spots have been described in some species, the number being from 2-8.

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A Catalog of the California Aleyrodidae and the Descriptions of Four New Species

By Donald D. Penny

Introduction

This paper consists of a list of the already described species of Aleyrodidae, or white flies, taken from the State of California, and a record of their food plants and localities together with the descriptions of four new species.

The writer has not attempted to give a systematic arrangement of the family in this paper but has laid much stress on the completeness of the list of food plants upon which the different species have been taken in order that from a knowledge of the food plants the family will be more readily accessible and at the same time may be kept up to date in respect to the host records.

In the collecting of specimens the writer has not been confined to any one section of the state but has taken and received specimens from a wide range of localities, including sections of both high and low elevation, from the extreme north to the extreme south of the state. This has resulted in the recording of some new hosts for the already described species as well as the finding of the four new species herein described.

The writer desires to thank Professor E. O. Essig for the many specimens given and other kind assistance rendered during the preparation of this paper.

Paratypes of the author's new species have been deposited with the collection of the California Academy of Sciences, Golden Gate Park, San Francisco, California.

Dialeurodes citri (Riley and Howard)
(*Aleyrodes citri* Riley and Howard)
Syn.: *aurantii* Maskell

1893—Insect Life, vol. 5, p. 219.

Food Plants.—*Ailanthus glandulosa*, *Allamanda neriifolia*, *Ampelopsis tricuspidata*, *Cerasus* sp., *Choisya ternata*, *Citrus* spp., *Coffea arabica*, *Diospyros kaki*, *Diospyros virginiana*, *Ficus macrophylla*, *Fraxinus lanceolata*, *Gardenia florida*, *Gardenia jasminoides*, *Hedera helix*, *Jasminum fruticans*, *Jasminum odoratissimum*, *Ligustrum amurense*, *Ligustrum* sp., *Maclura aurantiaca*, *Melia azedarach*, *Melia azedarach* var. *umbraculiformis*, *Myrtus communis*, *Magnolia fuscata*, *Myrtus lagerstroemia*, *Osmanthus amer-*

icanus, Prunus caroliniana, Prunus laurocerasus, Punica granatum, Pyrus sp., *Quercus aquatica, Smilax* sp., *Syringa vulgaris, Tecoma radicans, Viburnum tinus, Xanthoxylum clavaherculis.*

Localities.—At present this species is known to exist in the cities of Sacramento and Marysville. Also occurs in the Southern States—North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana and Texas.

Dialeurodes citrifolii (Morgan)
(*Aleyrodes citrifolii* Morgan)

Syn.: *nubifera* Berger

1910—E. W. Berger-Bull. 103, Fla. Agr. Exp. Sta. (A. nubifera).

Food Plants.—*Citrus* spp.

Localities.—Not in California at the present time, having been once exterminated at Bakersfield. Also recorded from Mississippi, North Carolina, Louisiana, Florida, Cuba, China, Japan and India.

Aleuroplatus coronatus (Quaintance)
(*Aleurodes coronata* Quaintance)

1900—A. L. Quaintance, Tech. Ser. No. 8, Div. Entom. U. S. D. A., pp. 22-23. Orig. desc.

Food Plants.—*Arbutus menziesii, Castanea* sp., *Heteromeles arbutifolia, Quercus agrifolia, Quercus chrysolepis, Quercus densiflora.* Collected by the writer on *Rhamnus californica* at Collins Springs, May 1917.

Localities.—Alameda County, Collins Springs, Golden Gate Park, King's Mountain, Los Angeles, Mendocino County, Pomona, San Bernardino, Santa Catalina Islands, Santa Clara Valley, Santa Cruz Range, San Ramon Valley, Santa Rosa, San Jacinto, Sierra Morena Range, Yosemite Valley.

Aleuroplatus gelatinosus (Cockerell)
(*Aleyrodes gelatinosus* Cockerell)

1898—T. D. A. Cockerell, Can. Entom. Vol. 30, p. 264. Orig. desc.

Food Plants.—*Quercus agrifolia, Quercus arizonica.* Collected by the writer on *Rhamnus californica* at Collins Springs, May 1917.

Localities.—Collins Springs. Collected by E. O. Essig at Auburn and Placerville. Also occurs in Arizona (type locality),

Pealius kelloggi (Bemis)
(Aleyrodes kelloggi Bemis)

1904—Bemis. Proc. U. S. Nat. Mus., Vol. 27, p. 499. Orig. desc.

Food Plants.—*Prunus ilicifolia, Quercus agrifolia.* Collected by E. O. Essig on Catalina cherry, Pasadena, Dec. 1914. Also Niles.

Localities.—Niles, Pasadena, Santa Clara County, Sierra Morena Range.

Pealius maskelli (Bemis)
(Aleyrodes maskelli Bemis)

1904.—Proc. U. S. Nat. Mus., vol. 27, p. 524. Orig desc.

Food Plant.—*Quercus densiflora.*

Localities.—King's Mountain, La Honda.

Bemisia inconspicua (Quaintance)
(Aleurodes inconspicua Quaintance)

1900—A. L. Quaintance. Tech. Ser. No. 8, Div. Ent. U. S. D. A., pp. 28-29. Orig. desc.

Food Plants.—*Arbutus menziesii, Clematis ligusticifolia, Heteromeles arbutifolia,* okra, *Physalis* sp., *Quercus agrifolia, Quercus densiflora, Rhamnus californica, Rhamnus crocea,* sweet potato, *Umbellularia californica.* Collected by the writer on *Acer macrophyllum,* Los Gatos, October 1916.

Localities.—Haywards, Los Gatos, Santa Cruz and Sierra Morena mountains. Also recorded by Quaintance from Florida.

Aleyrodes amnicola Bemis

1904—Proc. U. S. Nat. Mus., vol. 27, p. 514. Orig. desc.

Food Plants.—*Salix laevigata, Washingtonia nuda.*

Localities.—Stevens Creek.

Aleyrodes essigi, new species

Larva:—Color pale yellow with orange colored visceral glands in abdominal region; shape flat, elliptical, broadest in the abdominal region. The dorsum is free from wax but there is a lateral fringe of coalesced, white, wax rods. Segments of the case distinct. Marginal crenulations well rounded and incisions deep. Cephalic margin with a pair of short, delicate setae; caudal margin with long caudal setae set in tubercled bases; latero-caudal margins with a pair of small setae and a similar pair just within the latero-caudal margins.

Pupa-case:—Size 0.92 mm. by 0.53 mm.; shape elliptical; color transparent white with developing adult within light yellow. There is a vertical ventral fringe of closely coalesced, white, wax rods extending to the leaf. This fringe may be seen adhering to the leaf in the form of a ring when the case is removed. Secretions of the dorsum are lacking. The segments of the dorsum are distinct. The abdomen bears two parallel rows of irregular depressions which are indistinct in some cases. Vasiform orifice subsemielliptical with the cephalic margin straight. Operculum subrectangular, curved laterally, the distal end truncate extending one-half the length of the orifice. Lingula cylindrical extending about seven-eighths of the length of the orifice, densely setose at its distal end which bears a pair of small lobes and a pair of long, straight setae projecting caudad. There are other setae on the

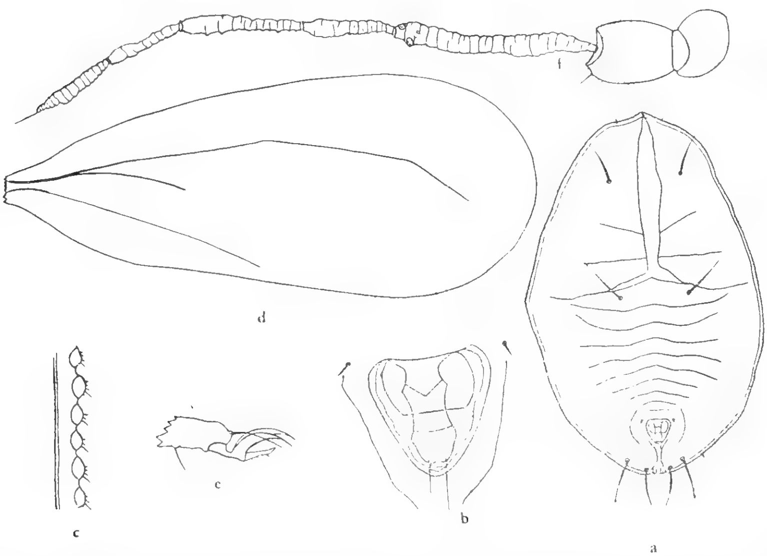


Fig. 1. *Aleyrodes essigi* n. sp. a, pupa-case; b, vasiform orifice; c, anterior margin of the forewing; d, forewing; e, claw of the adult; f, antenna of the adult.

case as follows: a small, delicate pair on the cephalic margin, a long pair in the cephalic region, an equally long pair on the first abdominal segment, a minute pair opposite the lateral extremities of the cephalic margin of the vasiform orifice, a long pair set in tubercled bases just within the caudal margin and a very small pair on the latero-caudal margin. The case must be handled carefully in mounting to prevent breaking these setae. The submarginal area is not set off from the dorsum by a raised ridge or depression. The margin of the case is evenly crenulated, the

incisions shallow except at the caudal margin where they become deeper and the wax tubes longer and narrower. The thoracic tracheal folds are not evident.

Adult female:—Length 1.2 mm.; general color light yellow with head and thorax darker than abdomen. Legs and mentum dusky. Paronychium blade-like; wings immaculate. Forewing length 1.2 mm., width 0.40 mm. Radial sector, media and cubitus present; radial sector with two flexures. Media short; cubitus a faint line except at the base. Antennae dusky; average lengths of segments as follows: segment 1, 0.024 mm., segment 2, 0.158 mm., segment 3, 0.109 mm., segment 4, 0.062 mm., segment 5, 0.072, segment 6, 0.044 mm., segment 7, 0.056 mm. Eyes very dark red, constricted but not divided.

This species was collected by Professor E. O. Essig, for whom the species is named, on *Ulmus* sp. at Mission San Jose, September 1916.

Aleyrodes pruinosa Bemis

1904—Proc. U. S. Nat. Mus., vol. 27, p. 491.

Food Plant.—*Heteromeles arbutifolia.*

Localities.—Berkeley, Catalina Islands, Leland Stanford Jr. University.

Aleyrodes spiraeoides Quaintance

1900—A. L. Quaintance. Tech. Ser. No. 8, Div. Entom. U. S. D. A., pp. 36-38. Orig. desc.

Food Plants.—*Aesculus californica, Convolvulus sepium, Lonicera involucrata, Nicotiana glauca, Opulaster capitatus, Plantago major, Sonchus oleraceus, Solanum douglasii, Troximon* sp. Collected by the writer on *Asclepias* sp., at Berkeley, October 1916 and in Santa Cruz County, November 1920; *Ceanothus* sp., Los Gatos, December 1917; *Hypericum androsamum* on the University of California Campus, November 1916; *Melaleuca hypericifolia* on the University of California Campus, November 1916 and on Pentastamen at Capitola, December 1917.

Localities.—Alameda, Berkeley, Los Angeles, Los Gatos, Santa Cruz County.

Aleurotulus nephrolepidis (Quaintance)

Syn.: *extraniens* Bemis

1900—A. L. Quaintance. Tech. Ser. No. 8, Div. Entom. U. S. D. A., pp. 29-30. Orig. desc.

Food Plants.—*Acrostichum capense, nephrolepis.*

Localities.—Conservatories of San Francisco. Type locality, Pennsylvania.

Aleurothrixus interrogationis (Bemis)
(*Aleyrodes interrogationis* (Bemis)

1904—Bemis, Proc. U. S. Nat. Mus., vol. 27, p. 516.

Food Plant.—*Ceanothus californicus.*

Localities.—Black and King's mountains, Pacific Congress Springs.

Aleuroparadoxus iridescens (Bemis)
(*Aleyrodes iridescens* Bemis)

1904—Bemis, Proc. U. S. Nat. Mus., vol. 27, p. 487. Orig. desc.

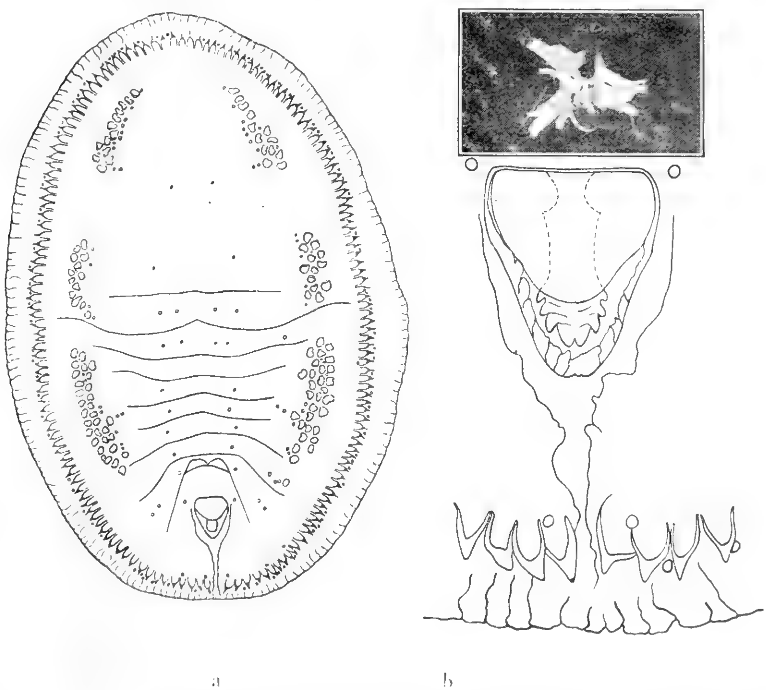
Food Plants.—*Arctostaphylos manzanita, Heteromeles arbutifolia, Rhamnus californica, Rhamnus crocea, Umbellularia californica.* Collected by the writer on *Salvia* sp., San Diego County, May 1917.

Localities.—King's Mountain, Yosemite Valley, San Diego County, San Gabriel Mountains, Santa Clara Valley, Santa Cruz Mountains.

Asterochiton corollis, new species

Pupa-case:—Size 0.90 mm. by 0.61 mm.; shape elliptical with the caudal end truncate; color dark brown. The wax secretion of the dorsum, as observed from somewhat imperfect specimens, consists of three separate systems as follows; first, a continuous marginal fringe extending entirely around the case, the rods of which are short and loosely joined, projecting directly toward the leaf to about one-half of the distance from the margin to the leaf. Second, a series extending continuously around the case just within the margin. The rods of this system are long, white and closely coalesced at their bases and extend upward for the greater part of their lengths then outward over the case, separating into ribbon-like structures at their extremities. Third, a series of short, thick rods arranged in groups which arise mesad of the second system and which project toward the center of the case. In addition to the dorsal wax the pupa case secretes a high vertical fringe of wax on which the case rests. The submarginal area bears a row of large, conical, papilla-like pores the bases of which are close together, the pores themselves measuring about 0.02 mm. in length. These pores undoubtedly secrete the long ribbon-like wax structure. On the dorsum proper are irregularly shaped, conspicuous, pore-like openings which are arranged in groups, the outer margins of which conform to the general curve of the case. These groups are found as follows: two in the cephalic region consisting of fourteen pores each, two in the thoracic region containing about twelve openings each and two in the abdominal region containing twenty-four each. Scattered through these pores are numerous very small circular pores also two pair of similar circular pores

in the cephalic region close to the median line, two pair on each segment of the thorax, two pair each on segments 1 and 2 of the abdomen, one pair each on segment 3, 4, 5 and 6 and three pair on segment 7 of the abdomen. In the submarginal area between the papilla-like pores and the margin is a row of the small circular pores and in addition to these some may be found with no apparent regularity near the bases of the submarginal papilla pores. The sutures of the case are distinct, the last three of the abdomen strongly reflexed caudad. The crenulations of the margin are broad and the incisions shallow. The submarginal area is not set off by a raised ridge or depression. Vasiform orifice subcordate, with the anterior margin straight, the lateral margins with corrugations or folds extending inward and downward; operculum shaped similar to that of the orifice with the caudal end slightly truncate, one-half filling the orifice; lingula subspatulate, densely setose, extending about three-fourths of the length of the orifice, bearing at its distal extremity three pair of lateral lobes and a pair of terminal lobes. Thoracic tracheal folds not evident. Just laterad of the anterior margin of the vasiform orifice is a pair of



a b

Fig. 2. *Asterochiton corollis* n. sp. a, pupa-case; b, vasiform orifice, caudal furrow and section of the caudal margin; c, pupa-case showing the wax secretions.

fine, delicate hairs set in circular bases. Delicate latero-caudal marginal hairs are present but cephalo-marginal hairs and caudal spines are lacking.

Adults unknown.

This species was described from three specimens of the pupa taken by the writer on *Arctostaphylos manzanita* at Pine Hills, San Diego County, May 1917.

Locality.—Pine Hills. (type)

Asterochiton diasemus (Bemis)
(*Aleyrodes diasemus* Bemis)

1904—Bemis. Proc. U. S. Nat. Mus. vol. 27, p. 516. Orig. desc.

Food Plants.—*Ribes glutinosum, Symphoricarpos racemosus.*

Localities.—Alameda, King's Mountain, Leland Stanford Junior University, Menlo Park, San Francisquito Creek.

Asterochiton diminutis, new species

Pupa case:—Size 0.53 mm. by 0.33 mm., shape elliptical, very convex, extending high above the leaf particularly in the cephalic region the ventral surface of which is projected into a blunt point. Color smoky white, parasitized specimens very dark brown. The wax secretion of the dorsum consists of an irregular row of tapering, glassy, white, waxen rods arising in the submarginal area and which extend upward and outward over the margin of the case and are about as long as one-third the width of the case; also

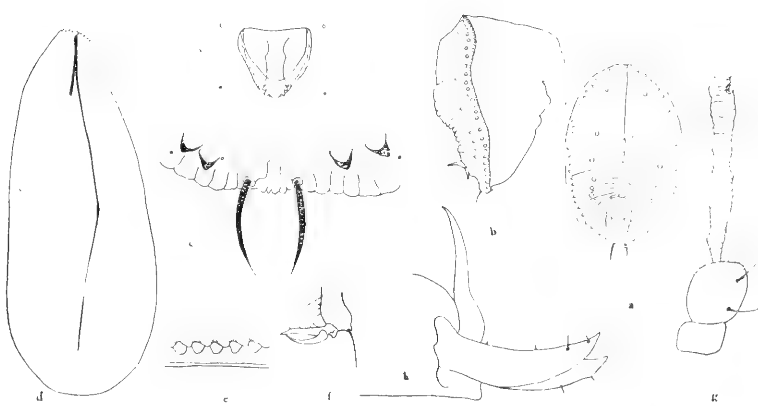


Fig. 3. *Asterochiton diminutis* n. sp. a, pupa-case; b, side view of the pupa-case; c, vasiform orifice and section of the caudal margin; d, fore-wing of the adult; e, anterior margin of the forewing; f, claw of the adult; g, first three segments of the antenna of the adult; h, male genitalia.

a pair of similar waxen rods arising in the cephalic region and extending upward over the case, a pair each on two segments of the thorax and on segments 3, 4, 5 and 6 of the abdomen. In addition to the dorsal secretion the case bears a continuous high, vertical fringe of coalesced, white, wax rods which extend from the margin of the case to the leaf. This wax functions as a support for the case and it remains firmly attached to the leaf when the case is removed. The pores which give rise to the dorsal wax secretion are large, 0.012 mm. in length, conical in shape and are arranged in a rather irregular submarginal row of about sixty in number; also a pair of similar pores in the cephalic region, a pair each on the two segments of the thorax and a pair each on segments 3, 4, 5 and 6 of the abdomen. Between the bases of the submarginal wax pores may be found very small circular pores, a row of similar circular pores between these and the margin of the case, and along the dorso-meson from the cephalic region to the vasiform orifice a pair for each segment, though occasionally missing on some segments. Segments of the dorsum are distinct and in the abdominal region the sutures are strongly bent caudad. Vasiform orifice subcordate, length 0.06 mm., anterior margin straight, inner lateral margins with corrugations extending downward. Operculum subsemielliptical, about one-half filling the orifice. Lingula slightly hidden, subspatulate, densely setose, projecting slightly beyond the orifice and bearing at its distal extremity a pair of terminal and three pair of lateral lobes. Submarginal area not set off from the dorsum by a raised ridge or depression. Thoracic tracheal folds not visible. Conspicuous caudal spines present, arising just within the caudal margin, but cephalo-marginal and latero-caudal marginal spines absent.

Adult female:—Length 1.0 mm., general color yellow to orange, eyes very dark brown, constricted but not divided. Forewing length 1.15 mm., radial sector, media and cubitus present. The radial sector is the main vein of the wing extending through the central area. The media is reduced to a remnant, being very short and faint and arising as a branch of the radial sector. The cubitus appears as a cleared line arising independently of the radial sector and projecting caudad toward the margin then paralleling it for a very short distance before ending. The portion of the wing through which the cubitus passes is very slightly dusky or unclear thus making the cleared vein more distinct.* Length of antennae segments from segment 1 to segment 7 inclusive, as follows: 0.024 mm., 0.052 mm., 0.128 mm., 0.048 mm., 0.064 mm., 0.044 mm., 0.040 mm. Paronychium blade-like.

This species was described from an abundance of pupae and several adults taken by the writer on tarweed (*Chamaebatia*

*This type of vein is spoken of by Bemis (Proceedings of the U. S. Nat Museum, vol. 27, page 493) as a long, oblique, anal fold.

foliolosa) at Placerville, May, 1918. The pupae occur on both sides of the leaves but the very small size of the pupa case together with the numerous minute leaflets on which the case rests make it exceedingly difficult to observe with the naked eye.

Locality.—Placerville. (type)

Asterochiton glacialis (Bemis)
(*Aleyrodes glacialis* Bemis)

1904—Bemis. Proc. U. S. Nat. Mus., vol. 27, p. 518. Orig. desc.

Food Plants.—*Ceanothus californicus, Clematis ligusticifolia, Opulaster capitatus, Quercus densiflora, Rhamnus californica, Rubus vitifolius, Symphoricarpos racemosus.* Taken by the writer on a *Salvia* hybrid on the University of California campus, November 1916.

Localities.—Alameda, Berkeley, King's Mountain, Santa Clara Valley, Santa Cruz and Santa Morena ranges.

Asterochiton hutchingsi (Bemis)
(*Aleyrodes hutchingsi* Bemis)

1904—Bemis. Proc. U. S. Nat. Mus., vol. 27, p. 532. Orig desc.

Food Plant.—*Arctostaphylos* sp.

Locality.—Yosemite Valley.

Asterochiton madroni (Bemis)
(*Aleyrodes madroni* Bemis)

1904—Bemis. Proc. U. S. Nat. Mus., vol. 27, p. 507. Orig desc.

Food Plant.—*Arbutus menziesii.*

Localities.—King's Mountain. Collected by the writer at Berkeley, Los Gatos, Santa Cruz County.

Asterochiton merlini (Bemis)
(*Aleyrodes merlini* (Bemis)

1904—Bemis. Proc. U. S. Nat Mus., vol. 27, p. 512. Orig. desc.

Food Plants.—*Arbutus menziesii.* Collected on *Arctostaphylos* spp. by E. H. Davis in San Diego County and by the writer on *Arctostaphylos* sp. at Colfax, April 1920.

Localities.—Auburn, Colfax, King's Mountain, Placerville, San Diego County. (Throughout Sierra Nevada Mountains.)

Asterochiton tentaculatus (Bemis)
(*Aleyrodes tentaculatus* Bemis)

1904—Bemis. Proc. U. S. Nat. Mus. vol. 27, p. 494. Orig. desc.

Food Plants.—*Clematis ligusticifolia, Lonicera involucrata, Opulaster capitatus, Quercus agrifolia, Quercus densiflora, Rhus diversabola.*

Locality.—Alameda.

Asterochiton vaporariorum (Westwood)
(*Aleyrodes vaporariorum* Westwood)

Syn.: *nicotianae* Maskell
Syn.: *papillifer* Maskell
Syn.: *lecanioides* Maskell

1856—Westwood. Gard. Chron., p. 852. Orig. desc.

Food Plants.—*Ageratum, Aphelandra, Aster,* bean, *Begonia, Bignonia, Capsicum, Chrysanthemum, Citrullus vulgarts, Coleus, Cucumis melo, Cucumis sativus, Fragaria* sp., *Geranium, Gonolobus, Lactuca sativa, Lantana commara, Nicotiana, Oxalis, Pelargonium Persea gratissima, Primula vulgaris, Rosa* sp., *Rubus, Salvia splendens, Solanum melongina, Solanum pseudo-capsicum, Tecoma, Vitis.* Collected by the writer on *Abutilon* sp., Santa Cruz county, July 1917; on *Aralia cordata,* October 1916, *Datura sanguinata,* November 1916, *Helianthus californicus,* November 1916, *Eupatorium ruparium,* November 1916 on the University of California Campus; on *Quercus kelloggi,* Santa Cruz county, June 1919, on *Rhamnus californica,* Los Gatos, November 1916 and on *Rhus diversiloba,* Santa Cruz county, September 1918.

Localities.—Berkeley, Los Gatos, Santa Cruz County, Santa Rosa.

Asterochiton vittatus (Quaintance)
(*Aleurodes vittata* Quaintance)

1900—A. L. Quaintance. Tech. Ser. No. 8, Bur. Entom. U. S. D. A., p. 42, Orig. desc.

Food Plant.—Chapparal.

Localities.—Claremont, Ontario, Pomona.

Asterochiton wellmanae (Bemis)
(*Aleyrodes wellmanae* Bemis)

1904—Bemis. Proc. U. S. Nat. Mus. vol. 27, p. 525. Orig. desc.

Food Plant.—*Rhamnus californica.*

Localities.—Leland Stanford Junior University, Stevens Creek.

Tetraleurodes acaciae (Quaintance)
(*Aleyrodes acaciae* Quaintance)

1900—A. L. Quaintance, Tech. Ser. No. 8. Div. Entom. U. S. D. A., pp. 19-20. Orig. desc.

Food Plants.—*Acacia, Bensera microphylla, Rhamnus californica.*

Localities.—Fullerton, Los Angeles, Ontario. Also recorded from Lower California and Mexico.

Tetraleurodes dorseyi (Kirkaldy)
(Aleyrodes dorseyi Kirkaldy)
Syn.: *quaintancei* Bemis

1907—Kirkaldy. Bul. 2 Div. Ent. Bd. Comm. Agr. & Forestry, Hawaii, p 52.

Food Plant.—*Rhamnus crocea.*

Locality.—Stevens Creek.

Tetraleurodes errans (Bemis)
(Aleyrodes errans Bemis)

1904—Bemis. Proc. U. S. Nat. Mus., vol. 27, p. 500. Orig. desc.

Food Plants.—*Arbutus menziesii, Umbellularia californica.* Collected by the writer on *Aesculus californica,* University of California Campus, September 1916.

Localities.—Berkeley, King's Mountain, Leland Stanford Junior University, San Ramon Creek, Santa Clara Valley, Santa Cruz Mountains, Redwood creek, Usal.

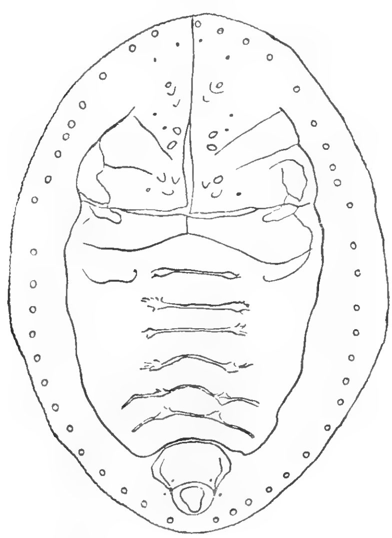
Tetraleurodes herberti, new species

Pupa-case:—Average size 0.92 mm. by 0.64 mm.; shape subelliptical, slightly more pointed at the caudal end; color shining black. The case is closely applied to the leaf. Dorsum keeled along the median line with the raised area somewhat wider in the cephalic and thoracic regions than in the abdominal region. The segments are distinct with suture lines well defined, particularly across the keeled area. Outlines of rudimentary legs on the ventral surface plainly visible through the case. In the cephalic region on both sides of the median line is a circular mark or depression which is bounded by two markings arranged as arcs of concentric circles. Caudad of these markings and close to the median line on either side is another group of two subcircular, clearly defined markings or pore-like openings, one latero-caudad of the other. In the thoracic region is still another pair of triangularly arranged groups of three irregularly outlined depressions, a pair on each segment suture from the thoraco abdominal suture to the vasiform orifice. In the cephalic and thoracic region on either side of the median line is a row of about five small circular pores which passes just laterad of the groups of markings in those regions to and including the first abdominal segment. Smaller circular pores are present just caudad of the abdominal depressions, one for each depression. A pair of similar pores are found just cephalo-laterad of the anterior margin of the vasiform orifice, another pair laterad and still another pair just cephalad of the anterior margin of the vasiform orifice. Vasiform orifice subovate, surrounded by thickened integument and raised well above the general level of the dorsum; operculum filling the opening.

Lingula partially obscured, spatulate, distal end spherical and densely setose. The submarginal area bears a continuous row of conspicuous circular pores which are about 0.014 mm. in diameter and which project somewhat from the case. The submarginal area is set off from the dorsum proper by a raised ridge which is continuous around the case save in the cephalic region. The crenulations of the margin are broad and well rounded, the incisions shallow. Marginal wax tubes project mesad about one-third the width of the margin. Thoracic tracheal folds not evident. A pair of fine, delicate caudal spines are present just within the caudal margin, set in tubercled bases. On the suture lines extending cephalad from the vasiform orifice is a pair of very fine delicate hairs set in circular bases. Cephalo-lateral and caudo-lateral marginal spines are lacking.

Adult:—Length about 0.65 mm.; color yellow with the head and thorax lighter. Eyes dark red, constricted but not divided. Wings immaculate, forewing with Radius 1, cubitus and media present; media short, faint and poorly defined. Paronychium blade-like. The antennae of all specimens were broken.

Described from material taken by F. W. Herbert, for whom the species is named, at Pleasanton, Alameda County, October 1918,



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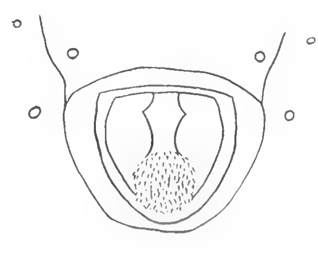

b

Fig. 4. *Tetraleurodes herbeti* n. sp. a, pupa-case; b, vasiform orifice.

on black locust. The specimens consisted of pupae with only three adults which were badly damaged. The pupae were attached to both sides of the leaf.

Localities.—Pleasanton. (type)

Tetraleurodes melanops (Cockerell)
(*Aleyrodes melanops* Cockerell)

1903—Cockerell. Bul. 67. Fla. Agr. Expt. Sta. p. 665.

Food Plant.—*Quercus* sp.

Localities.—Alpine Tavern, Mt. Lowe.

Tetraleurodes nigrans (Bemis)
(*Aleyrodes nigrans* Bemis)

1904—Bemis. Proc. U. S. Nat. Mus. vol. 27, p. 522.

Food Plants.—*Arbutus menziesii, Arctostaphylos manzanita, Ceanothus californicus, Clematis ligusticifolia, Eriodictyon californicum, Heteromeles arbutifolia, Lonicera involucrata, Prunus ilicifolia, Rhamnus californica, Symphoricarpos racemosus, Umbellularia californica.* Collected by the writer on *Salvia* sp., Corona, May 1917.

Localities.—Corona, Black and Kings Mountains, Pacific Congress Springs, San Ramon Valley, Santa Clara Valley, Santa Cruz Range, slopes of Sierra Morena Range, Stevens Creek.

Tetraleurodes perileuca (Cockerell)
(*Aleyrodes perileucus* Cockerell)

1903—Cockerell. Bul. 67, Fla. Agr. Exp. Sta., p. 664.

Food Plant.—*Quercus* sp.

Localities.—La Jolla.

Tetraleurodes splendens (Bemis)
(*Aleyrodes splendens* Bemis)

1904—Bemis. Proc. U. S. Nat. Mus. vol. 27, p. 489.

Food Plants.—*Rhamnus californica, Arctostaphylos* sp.

Localities.—Leland Stanford Junior University, Yosemite Valley.

Tetraleurodes stanfordi (Bemis)
(*Aleyrodes stanfordi* Bemis)

1904—Bemis. Proc. U. S. Nat. Mus. vol. 27, p. 508.

Food Plants.—*Quercus agrifolia, Quercus densiflora.* Collected by the writer on *Rhamnus* sp., Fresno, May 1917.

Localities.—Big River, Mendocino County, Black Mountain, Fresno, King's Mountain, Santa Clara Valley.

References:—The writer has made use of all available works dealing with the descriptions of the species of the family of Aleyrodidae and especially the following:

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"The Aleyrodids, or Mealy-winged Flies, of California, with References to Other American Species," by Florence E. Bemis. Proceedings of the United States National Museum, vol. 37, pages 471-537, 1904.

"Classification of the Aleyrodidae," Part I and II, by Quaintance and Baker. Technical Series, No. 27, Bur. Entom. U. S. Department of Agriculture, 1913, 1914.

"A Contribution to Our Knowledge of the White Flies of the Subfamily Aleyrodinae (Aleyrodidae)," by Quaintance and Baker. Proceedings of the United States National Museum, vol. 51, pages 335-445, 1917.

Preliminary Notes on Growth-Stages in Brittle-Stars

Arthur S. Campbell

There are a number of conditions to account for our present lack of a rational system of the brittle-stars. One of the principal reasons why the group is so difficult to classify lies in the profound ignorance of their growth-changes. The excellent systematic work of Ljungman, Lutkin, Lyman, Koehler and the two Clarks have brought some thousand species to attention but the real relationship of these as larger groups is yet quite unsolved. There have been several attempts to rationalize the classification, one by Bell, 1892, and more recently by Matsumoto, 1915. Neither of these systems is thoroughly based upon phylogenetic history, and hence, cannot be conclusive since the state of our present knowledge is such as to forbid any sweeping generalizations.

Although the chief reason for our lack of a rational system in the group is this lack of attention upon growth-stages, another lies in the general disregard of palaeontological evidence, and a further reason because attention has been focused upon larval, rather than post-larval, stages.

Material heretofore studied in connection with this problem of growth-stages in the young of ophiurans numbers less than one dozen species, all of which are Atlantic or West Indian forms. My own observations were made upon seven species, the members of five families. All are the members of the littoral fauna of Southern California. Specimens were collected in all accessible habitats and studied after preservation.

The excellent plates for this paper are the work of Miss E. Keyes, a student in Pomona College.

It is not always possible to tell just why one places a form in this or that group for many characters are subtile and one is obliged to depend very often upon general features. Especially is one dependent upon as complete a series as possible in placing a juvenile. H. L. Clark, in his paper on growth-changes in some brittle-stars expresses the only formulation of the very important contribution of R. T. Jackson to the study of juvenile brittle-stars that I have seen. This law is a very real help in determining possible relationships between specimens otherwise obscure or impossible to differentiate. Briefly stated, we may say that, as applied to these forms, the base of an arm of a young form corresponds exceedingly suggestively with the tip of an arm of an adult specimen of the same species. However, the extent of localization varies greatly in different species, as I have found. One needs much study to determine accurately the position of a given specimen.

It is hardly possible, as I have pointed out, to formulate a general system of the group but among the groups examined the *Ophiolepidae* and the *Ophiocomidae* are noticeably separate and, containing few local genera of well marked characters can readily be separated both among themselves and from other families. Between the families *Ophiothricidae* and *Amphiuridae* I have found many points of contact as I did also between some *Ophiodermatidae* and the *Amphiuridae*. Beyond these generalizations I do not care to advance any opinion.

Following are my results upon those species examined. Extremes of measurement and a few notes on certain of the more obvious structural details are given. Other details can be made out from study of the plates.

Ophiocryptus maculosus Clark. The smallest specimen measured had its disc one mm. in diameter and with arms one and a half mm. long. Young of this species differ from adults in few skeletal details. The buccal fissures seem less marked and the arms relatively longer in proportion to the disc.

Ophioderma panamensis Lutkin. The smallest specimen measured two mm. across the disc and with arms eight mm. long. Juveniles of this species resemble adults in many points but they differ in others. The disc is set well apart from the arms. The characteristic notches between the arms in the adults are absent. The radial shields are scarcely marked. The branchial spines are set almost at right angles to the arms. Not figured.

Ophioplocus esmarki Lyman. The smallest specimen measured was one mm. across the disc and with arms eight mm. long. Juveniles of *O. esmarki* are always distinguishable by pinkish bands crossing the arms. This species is especially interesting on account of the schizogony that young specimens undergo.

Amphiodia barbarae Lyman. The disc of the smallest specimen measured was three mm. and the arms twenty-eight mm. long. These are always to be distinguished by the exceedingly long arms at least ten times the diameter of the disc. Young seem to bear many points in common with *O. panamansis.*

Ophioneris annulata Le Conte. Specimens of this species vary from about one half mm. to two mm. in diameter. They undergo schizogony in an unequal plane in certain cases. Like the adults the arms have three flattened arm-spines and with banded arms.

Ophiopteris papillosa Lyman. Measurements of the smallest specimen in this species found were for the disc three mm. and for the arms ten mm. These are distinguishable by the flat upper arm-plates and coarse arm-spines, but these are both characters that vary even in one specimen.

Ophiothrix spiculata Le Conte. I found but few specimens of this although the adults are abundant. The smallest specimen measured one mm. in diameter. The reduction in the comparative

size of the radial shields is especially noticeable in a series of specimens. One of the interesting features of this species is the great range of color variation found. This is true both in young and adults.

CONCLUSIONS:

1. A rational system in the brittle-stars is lacking. Such a system may result in part at least, from a complete study of growth-stages.

2. Jackson's law of localized stages repeating phylogenetic history seems to be well vindicated in this and other studies.

3. The groups examined seem to bear certain relationships to each other, as indicated above.

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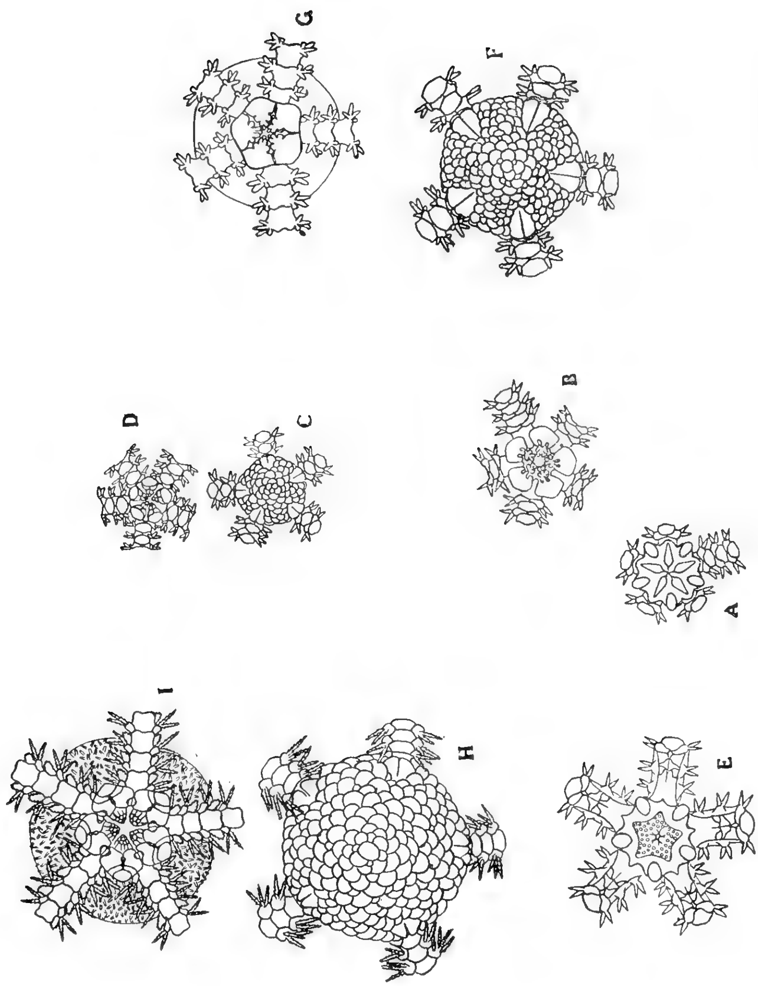

EXPLANATION OF PLATES

All figures X10

Plate I, *Ophiothrix spiculata.*

A, B; C, D; F, G; H, I, upper and lower surfaces of various sizes. E, Dorsal view of one whose ventral side is like A.

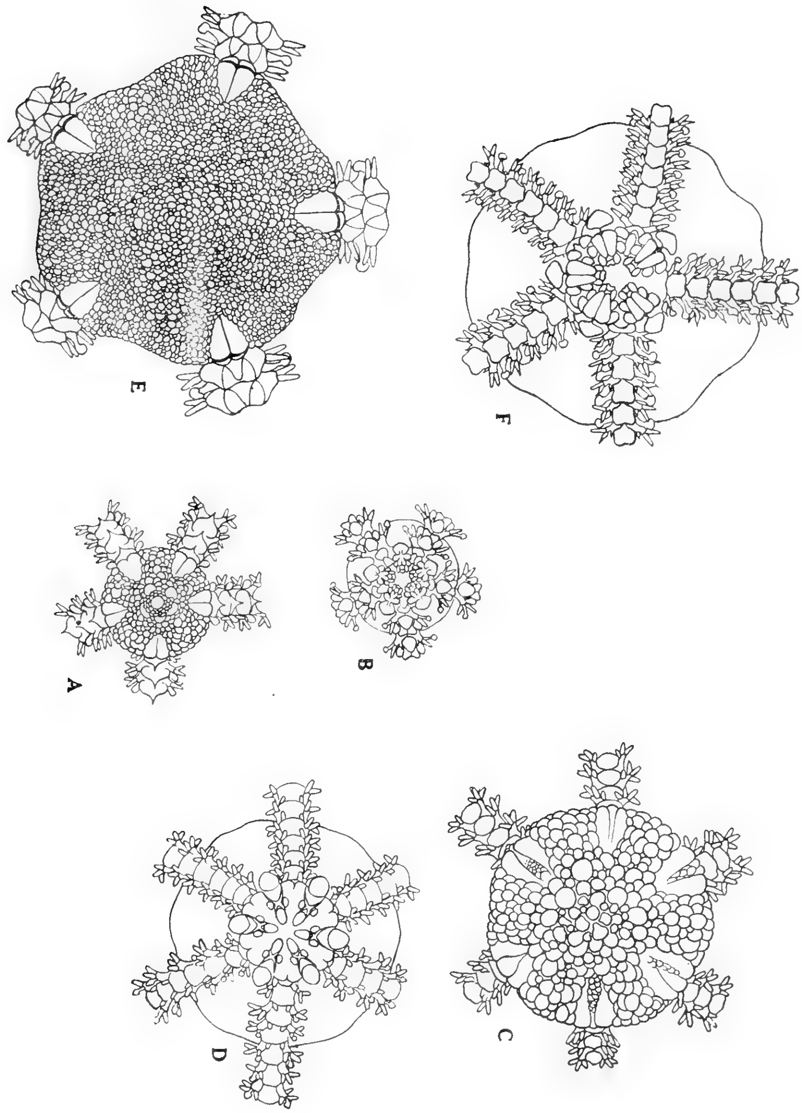

Plate III. A, B; E, F, *Amphipodia barbarae;* C, D, *Amphipodia barbarae?*

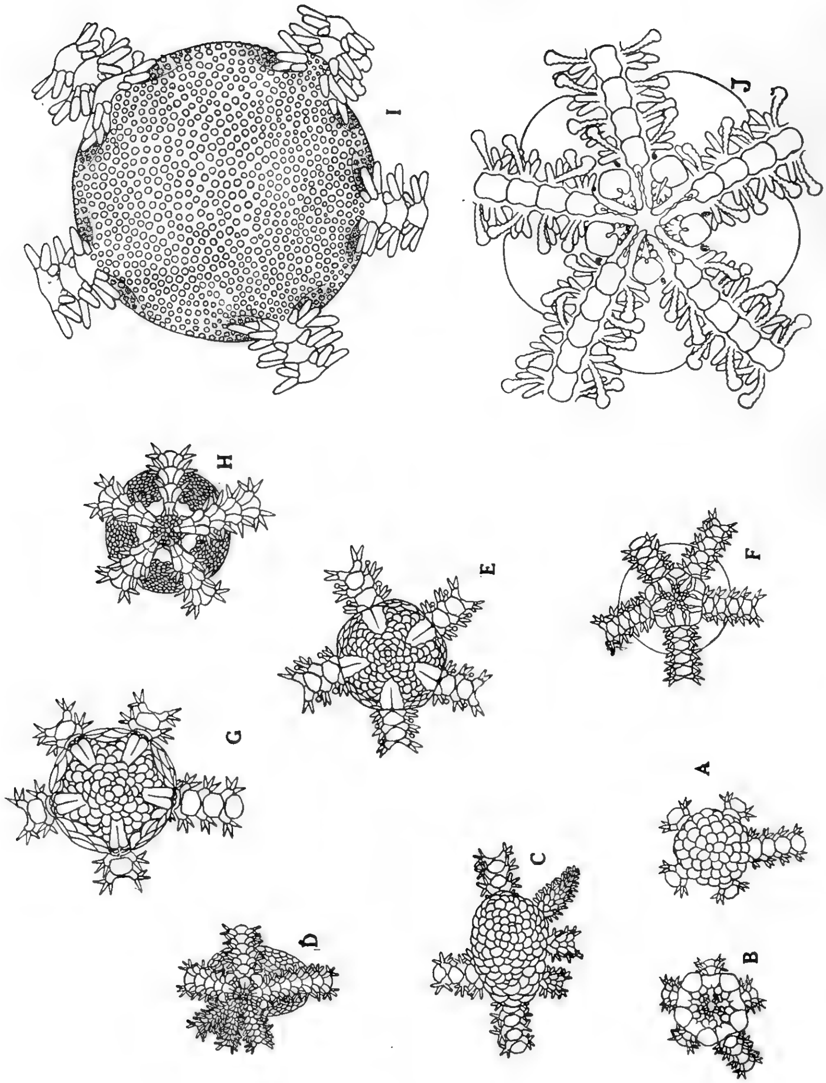

Plate II. A. and B, upper and lower surfaces of *Ophionermis annulata.*
C and D, upper and lower surfaces of six armed *O. annulata.*
E, F; G, H, upper and lower surfaces of *Ophioplocus esmarki.*
I, J, upper and lower surfaces of *Ophiopteris papillosa.*

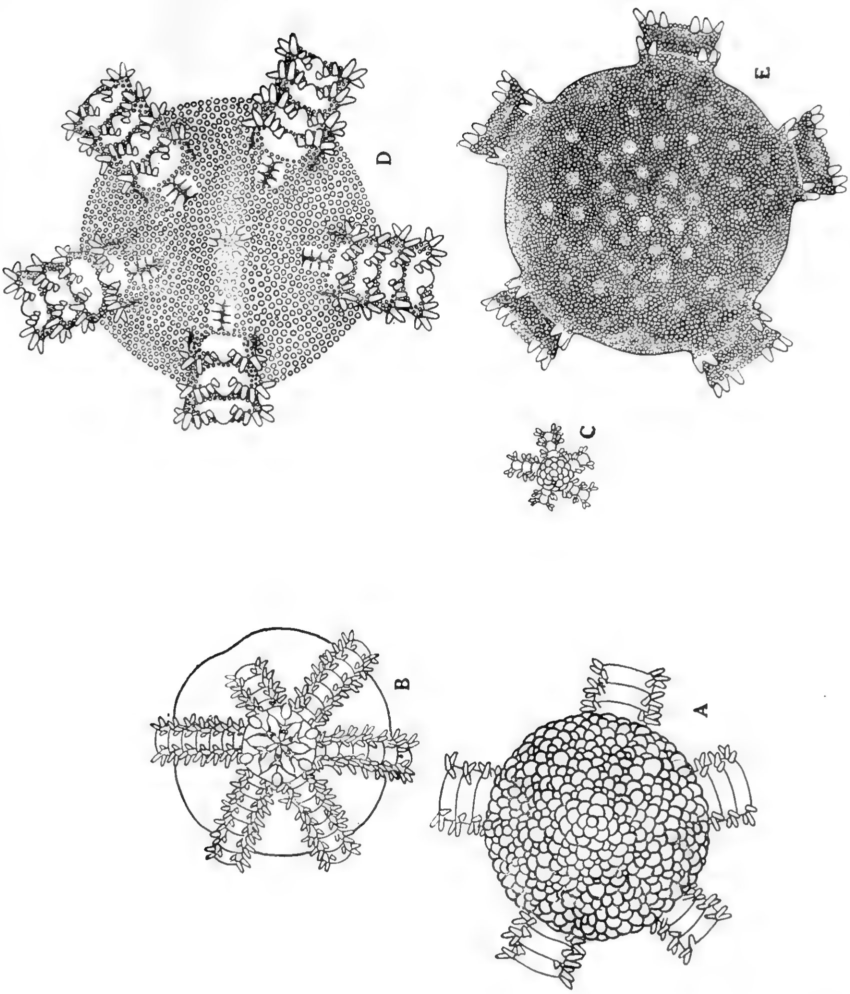

Plate IV. A, B, upper and lower surfaces of *O. annulata*. C, Dorsal, E, D, dorsal and ventral views of *Ophiocryptus maculosus*.

IX. The Bryozoa

Ectoprocta.

About the earliest observations on the nervous system of these animals was by Dumortier and Van Beneden in 1843. They described the central nervous system of fresh water forms as composed of two ganglia above the oesophagus joined by commissures. From the aboral part of the ganglion a pair of nerves runs to the oesophagus. They also considered that a pair of nerves supplied the epistome.

In 1848 Van Beneden speaks of but a single ganglion.

Allman, 1856, in fresh water forms describes a single unpaired oval ganglion. The two oesophageal nerves are represented as an oesophageal ring with enervation for the epistome.

Hyatt, 1865-1868, describes the central ganglion in *Plumatella* with the ganglion concentrated. The two long arms of the animal however, are capable of independent movement. The ganglion in *Trederecella* is spindle-shaped. In *Plumatella* the ganglion is kidney-shaped and as it doubles upon itself by movements of the animal it becomes heart-shaped. He describes a true nerve ring about the oesophagus. Nerves go to the middle and end intestine. Hyatt also describes nerves to the epistome and to the tentacles.

Nitche, 1869-76, has studied bryozoans quite extensively. He found a central cavity in the ganglion in embryonic stages. He recognized an oesophageal ring, intestinal nerves, tentacle nerves. He recognized on the tentacles bristles which he called taste bristles.

Claparede, 1871, in some bryozoans describes the nervous system of colonial forms; nerve strands running the length of the body were recognized.

Kraepelin, 1887, found the center of the ganglion in adult forms, and the shape of the ganglion of fresh water forms elipsoid. He also recognized peripheral ganglion cells in the ganglion. Oral nerves were seen, as well as nerves to the epistome.

Verworn, 1887, in a general way recognized ganglion cells.

Saefftiger, 1888, has especially added to our knowledge of the distribution of the nerves to the tentacle crown; he also considers a sympathetic system but says nothing of the sense cells in the tentacles although he describes the epithelium of parts of the animal.

Braem, 1890, describes the central ganglion of fresh water forms as hollow with an outer thinner oesophageal and a ventral thicker wall. He considers the inner part of the ganglion as largely fibrous.

Oka, 1891, has considered fresh water forms, especially *Pectinatella.* Like Saefftiger, he finds the ganglion with a cavity in the mature state. The ganglion is compared to a spindle bent in

the form of a U, with the concavity fitted to the anal side of the oesophagus in an oblique position with arms turned slightly upwards. The end of each makes a turn in the oral direction, and is continuous with a large nerve trunk which goes to the lophophore arm. The ganglion is in direct connection with the inner cell layer of the oesophagus, the outer layer of the latter enveloping it on all sides. The lophophore nerve trunks are likewise located between the outer and inner layers of the body-wall; they run beneath the outer layer of the lophophore covered below by epithelium. The ganglion contains a large cavity extending to the ends of the ganglion. The wall of the ventricle is very thin and epithelial in nature on all sides but the bottom on the anal side, where it is very thick as it joins the main part of the ganglion. This thick portion is distinctly separated from the epithelial part and is well seen in the fresh state as a somewhat reddish mass with a slight constriction in the median plane of the polype. It is this part that Hyatt took for the ganglion which he described as composed of two lateral masses connected by a thick commissure. The epithelial part is hard to recognize in surface views. A cross section of the lophophore trunks is kidney-shaped; in it the nerve cells are much crowded; the nerve cells are spindle-shaped, bipolar, with nuclei in the middle, closely packed together with few fibers between. The nerve trunks are thick and large as compared with the ganglia. The matter of a circum-oesophageal ring was not settled; this author did not find it. The colonial nervous system found in some marine Bryozoa for the purpose of controling the movements of the members of the colony seem to be entirely lacking in the species *Pectinatella gelatinosa*, and this fact agrees with the behavior of the animals as they act independently.

Cori, 1893, does not give much further information about the nervous system of bryozoans.

Delage and Herouard, 1897, in a number of diagrams show the position of the ganglion in marine ectoprocts as being a single small ganglion ventral to the oesophagus. There are probably nerves going to the tentacles, to the body and to the alimentary canal, but these are not clearly shown in any case. A ganglion in the avicularium is shown by Delage and Herouard and they indicate by a series of diagrams how this ganglion might have been derived from a single zooid by a series of gradual transformations.

Ladewig, 1900, shows such a ganglion center in an avicularium of a marine ectoproct.

The sensory system of ectoprocts has been described by Nitsche on the tentacles of *Alcyonella* as stiff bristles to which he ascribes the sense of taste. Verworn, Kraepelin, Braem and others have seen these without ascribing special functions to them. It seems probable that the tentacles must have some special sense organs for touch or other senses.

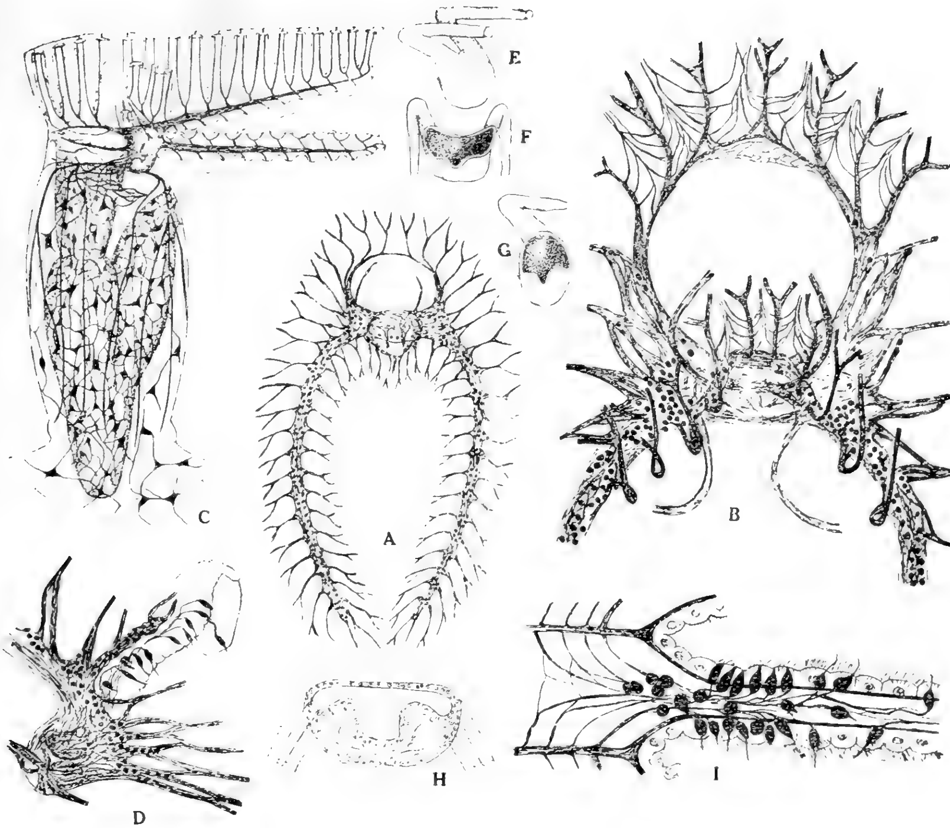

Fig. 19. NERVOUS SYSTEM OF FRESH WATER BRYOZOA. A. General view of the nervous system of *Cristatella*. B. Oral surface of upper end of central nervous system of *Cristatella*. C. General plan of the nervous system of *Cristatella*. The tentacles are all cut away in one arm and partly cut off in the other. The position of the alimentary canal is indicated. D. Side view of a portion of the chief ganglion showing the nerves of the epistome. E. Diagram of sense cells and nerve bands connected with a single tentacle. F. Diagram of a section from side to side of the central ganglion showing the cerebral cavity. A-D, I after Gerwerzhangen from *Cristatella*. E, F, G, and H. Surface longitudinal and cross sections through the ganglion of a fresh water bryozoan from Oka.

From the above review it will be evident that we know much more about the nervous system of fresh water forms than marine ectoprocts, and Gerwerzhagen, 1913, has still further extended our accurate knowledge of the nervous system of fresh water forms. Most of his information comes from the study of total preparations.

The general form of the nervous system is shown in Fig. 19A. The cerebral ganglion is connected with the two large ganglionic cords which have branches to the tentacles by way of the radial nerves, each of which has two branches. In the upper part of the figure is the oral nerve ring while below is the narrower epistomial nerve ring.

Fig. 19B. shows more detail in the region of the oral nerve ring and oesophageal plexus. It shows three bands of commissural fibers running across the cerebral ganglion.

Fig. 19C. shows the general outline of the whole animal with the tentacles partly cut away. Besides the general nerves there is the nerve plexus of the base which connects with that of other members of the colony.

Fig. 19D. is a side view of part of cerebral ganglion. The nerve supply to the epistome shows on the left.

Fig. 19I. shows the nerve supply to the base of a tentacle; two chief branches enter each tentacle, with sensory nerve cells.

Fig. 19D. shows a diagram of a cross section through the center of the cerebral ganglion.

In general then the nervous system of *Cristella* may be summarized as follows:

1. The ganglion is hollow with an extension into the two large ganglion cords.

2. There are two main branches running down each tentacle one from each adjoining radial nerve from the ganglinic cord. There are also strands from the bipolar sense cells in the epithelium of the tentacles. These afferent fibres join the radial nerves on each side.

3. There are two nerve rings, the epistomal or dorsal smaller one and the oral or ventral larger one, each with numerous secondary branches.

4. The sense cells in the tentacles, especially are bipolar. Multipolar cells are also found in the nervous system and nerve plexus.

5. There is a ganglion cell network in the wall which connects one member of the colony with another. This network joins

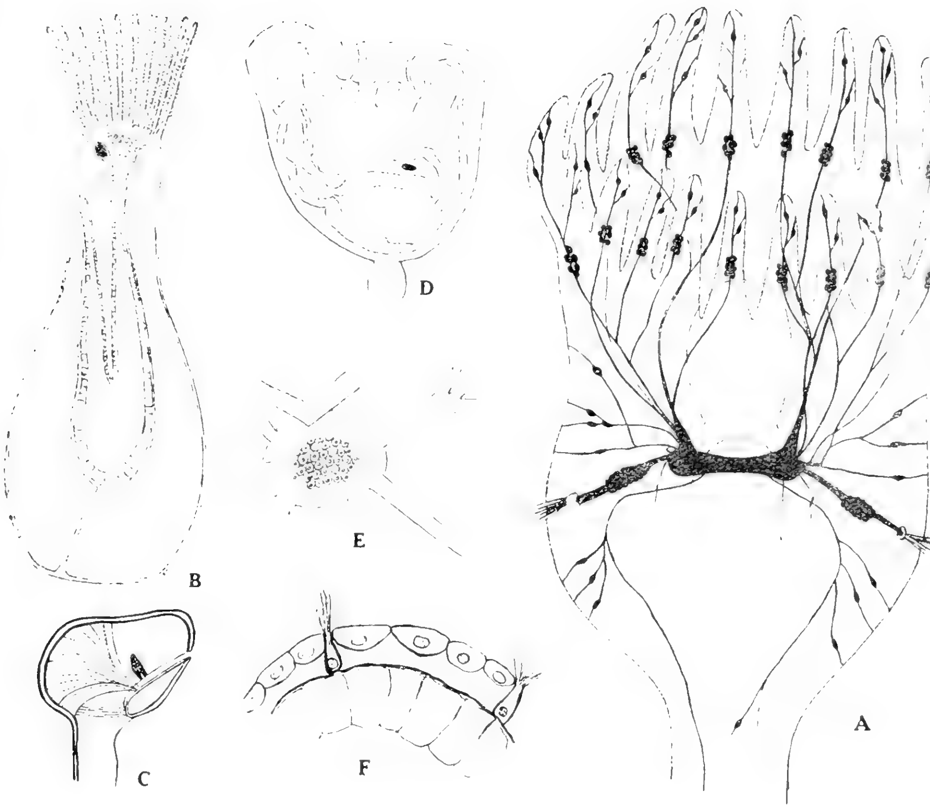

Fig. 20. BRYOZOA All but B and C from endoproctans. A. Diagram of the nervous system and sense cells of *Loxosoma*. Harmer. B. Longitudinal section of an estoproctan bryozoan from Delage and Herouard. The position of the ganglion is shown by a black area. C. An avicularian from *Bugula* showing ganglion after Ladewig. D. *Pedicellina* showing location of ganglion. E. Ganglion of *Pedicellina*. Nitsche. F. Diagram of sense cells in surface of tentacle of *Pedicellina*. Retzius.

with the similar multipolar network over the surface of the individual members of the colony. In the connecting portion of the colonial wall are no sensory cells so these nerve cells must have a motor function.

6. The sympathetic system is represented by fine nerves from the aboral surface of the ganglion to the dorsal and dorso-external wall of the oesophagus. Ventral fibers also join with the oral nerve ring by anastomoses.

There is a nerve network over the surface of the alimentary canal. At the beginning of the oesophagus and extending to the stomach there is a network of cells and fibers forming a sort of nerve ring. Further down all parts of the alimentary canal have a nerve plexus. The nerve net is especially abundant about the rectum. The function of the sympathetic system seems to be motor. The sympathetic system in the digestive canal consists of a nerve network of ganglion cells as well as stands of nerve fibers.

ENDOPROCTA.

Van Beneden, 1845, although he considers *Pedicellina*, gives little or nothing on the nervous system. Kowalewsky, 1867, discusses the development and Uljanin, 1869, gives the position of the ganglion in the same genus. Nitsche, 1875, shows the general position and chief branches of *Pedicellina*. Salensky, 1877, gives the general location of the ganglion in *Loxosoma*.

Harmer, 1885, gives one of the best early accounts of the nervous system of *Loxosoma*. He describes a dumb-bell-shaped ganglion, bipolar cells on the surface and a median fibrous part. Nerves pass from the ganglion to the tentacle prominences. There are many sense cells in the tentacles. Silver nitrate was used to determine the position of the sense cells. The ganglion is developed from the ectodermic floor of the vestibule and is connected with a well developed system of peripheral nerves ending in sense cells bearing tactile hairs on various parts of the body. The adult has no supraoesophageal ganglion. The nervous system of *Loxosoma* develops by ectodermic invaginations; the connection between the two parts is established secondarily.

Foettinger, 1887, represents the nervous system of *Pedicellina* by a brain more or less completely divided into two lateral lobes. It is formed by a mass of ganglion cells surrounding a fibrous center. From the ganglion several pairs of nerves pass.

Seeliger, 1890, gives the development and position of the nervous system in endoprocts.

Davenport, 1893, shows the position of the ganglion in *Unatella*.

Nickerson, 1901, in *L. davenporti* describes the brain as just in front of the intestine and above the stomach, between it and the

floor of the diaphragm. It is elongated transversely, the two rounded ends being composed of a surface layer of cells with deeper fibers. Some of the fibers form a commissure. From each end of the brain two bundles are given off; one on each side passes to the lophophore. Sensory bristles were seen from the tentacles. Dorsal sense organs as described in other forms are absent in this.

Stiasny, 1905, shows the ganglion of *Pedicellina* but with no detail. Retzius, 1905, shows the sensory nerves in the surface of *Pedicellina*. These sensory cells bear bristles and are connected with nerve strands which form a wide network of fibers. Sensory cells were found in the tentacles.

Assheton, 1912, found the nervous system in two species of *Loxosoma*. The branches are figured and sense cells are mentioned on the hypostome, lophophore and tentacles.

I have been able to study the reactions of two Pacific coast species of endoproctans. In *Barentsia gracilis* Hincks, the conditions are much as in *Pedicellina*. The ganglion is small and in the usual position. The animals are colonial with narrow strands connecting the individual members of the colony; the muscular bases of each individual cause them to rotate in an active manner. General conditions in *Myosoma spinosa* Robertson are similar except that the whole stem is flexible. In *Barentsia* the polype at the end of the stem is movable at its stalk. The ganglion is much as Nitsche describes. There is some indication of sense cells as shown by Harmer as demonstrated by the methylene blue method although I never obtained a perfect picture. The tip of the stem is slightly smaller where it joins the body of the individual and methylene blue shows bipolar cells at this point. Along the stem there are sensory pits which are the only breaks in the strong chitin-like covering of the ten elongated cells of the stem. In *Myosoma*, in place of the pits on the skin there are well developed hollow hairs much like those of arthropods.

Tactile or other stimuli may cause a rotation of the stems without a contraction of the tentacles, but severe stimuli will also cause the tentacles to contract. Stems with their tips cut from the body continue to rotate when stimulated. Movements of the body of the polype on the stems may be caused by tactile stimuli. The effects of stimulation may be carried from one polype to another through the connecting stems. One polype in line with others may be fatigued so that it will not carry the stimuli to others.

The stems and bases of both species seem capable of exciting movements of the individual as a whole better than the tentacles or body. In the rotating movements the tentacles are not often retracted unless the stimulus is very severe or the tentacles themselves are touched.

The control of movements of the tentacles and body are probably centered in the ganglion. The excitation to the rotation of

the stems is effective through the stems themselves and the presence of the ganglion is not necessary for these characteristic movements. The conduction from one member of the colony to another seems more evident than from the base or stem to the tentacle region, and vice versa.

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The Skull of Nototthalamus Torosus

Sarah Marimon

There are twenty-eight bones in the entire skull of *Notothalamus torosus.* There are, however, only fifteen different kinds, since thirteen are paired.

These paired bones are: nasals, ectethnoids, maxillaries, frontals, parietals, squamosals, quadrates, ptergoids, occipitals, squamopalatines, sphenethnoids, and (of the mandible) dentaries and articulaires.

The unpaired bones are: the parasphenoid and the premaxillary.

The premaxillary (1) is the bone which forms the external division between the two nares. It consists of a rather thin dividing bone, which broadens out to form a broad flat base. Dorsally the dividing bone diverges posteriorally to form two slender processes which join at the ends with the premaxillary processes of the frontal bones, and articulate on the exterior sides with the two nasal bones. Ventrally the dividing bone broadens out suddenly into a broad flat base which forms the most forward portion of the roof of the mouth, and serves as a connection between the two maxillaries.

The nasals (2) are two irregularly shaped bones, each of which articulates on the interior side with a premaxillary process, on the exterior side of the ectethnoid and the maxillary. Anteriorally the nasals bound the dorsal side of the nasal cavity.

The ectethnoids (3) are two triangular bones located on either

FIGURES

In lettering these figures I have used the following method:

Each bone on the skull is marked with a large number. Throughout the figures, each bone goes by its number. When an articulation with a certain bone is indicated a small figure is used. The bone itself bears a large figure. When the bone borders on a cavity, or has a free edge, that portion of the bone is not numbered.

Upper or outer surfaces are indicated by numbers, under or inner surfaces are indicated by the same numbers prime (1).

side of the anterior portion of the skull. Each is so placed that one half of its surface articulates with the dorsal surface of the skull, while the other half forms a portion of the side of the skull. Through the center of the ectethnoid there is a dividing ridge which separates its dorsal surface from its lateral surface. The dorsal surface articulates anteriorally with the maxillary and the nasal, and posteriorally with the frontal. The lateral surface articulates anteriorally with the maxillary and posteriorally with the frontal; a small portion remains between these two articulations and this portion bounds part of the opening into the olfactory fossa.

The maxillaries (4) are long slender bones, which, together with the premaxillaries bear the teeth of the upper jaw. The maxillary articulates only anteriorally and diverges posteriorally to form a long rather slender process extending about one-half the length of the skull. Before the maxillary articulates with the main body of the skull it diverges on the inner side into two portions; the upper portion articulates with the dorsal bones of the skull, while the lower portion articulates with the ventral bones. The

hollow depression resulting from these two divergences forms the opening into the olfactory fossa. Dorsally the maxillary articulates with the nasal and the ectethnoid; and ventrally with the premaxillary and the squamo-palatine.

The frontals (5) form a little less than one-half of the dorsal surface of the skull. They lie in contact with one another for about two-thirds of their length, diverging anteriorally to form a pair of short premaxillary processes, and diverging posteriorally to form two processes,—a blunt rather broad parietal process and a long slender process which articulates with the squamosal bone. On the ventral surface of each frontal is an out curving ridge which serves for the attachment with the sphenethnoid.

The parietals (6) lie in contact with one another for their entire length. They are smaller than the frontals, however, they form less of the dorsal surface of the skull than their real size would warrant, since at their articulations with the frontals these bones extend down over them. Posteriorally each parietal articulates with the occipital, and posterio-laterally with the occipital and the sphenethnoid.

The occipitals (10) are the most posteriorally placed bones in the skull. The dorsal surface of each is more or less regular, diverging toward the median line to form a short rather slender process which articulates with the other occipital. Anteriorally the occipital connects with the parietal while posteriorally on the external side, it articulates with the squamosal. The ventral surface of the occipital is very irregular and the articulations with other bones are not continuous. Posteriorally on the external side it diverges to form a short process, which unites with the squamosal and forms the posterior corner of the skull. On the inner aspect of the ventral surface, adjacent to the squamosal articulation, is a projecting knob-like process with which the ptergoid articulates.

The most posterior portion of the occipital toward the median line, diverges to form a knob-like condyle which articulates with the first vertebra. Anteriorally the occipital articulates with the parasphenoid and anterio-laterally diverges to form a projection which articulates with the sphenethnoid.

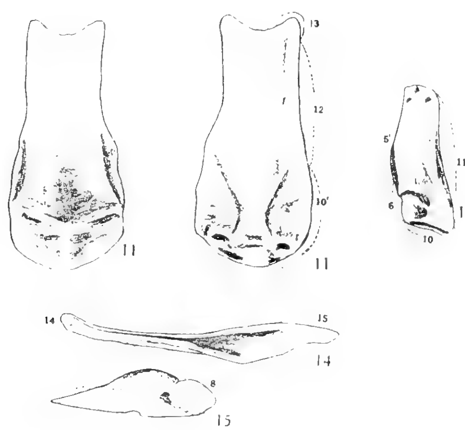
The squamosal (9) is a peculiar T-shaped bone, standing in an almost vertical position in the skull. The bar of the T, forms a part of the dorsal surface of the skull and articulates at the anterior end with the frontal bone; at the posterior end with and up past the point where the stem of the T diverges, it articulates with the occipital bone. The stem of the T projects ventrally almost at a right angle, and articulates with the ptergoid and the quadrate.

A true squamosal bone is sometimes considered not to exist among Amphibia, and the so-called squamosal bone is considered to be rather an investing bone on the surface of the quadrate, and for this reason is sometimes called the paraquadrate.

The quadrate (8) is an irregularly shaped little bone with somewhat the appearance when in position, of a wedge between the ptergoid and the squamosal. Functionally it serves as a piece interposed between the skull and the mandible, and forming an articular surface for the latter. The knob-like anterior ventral end of the quadrate consists of an articular process, fitted with a socket to receive the rounded knob (articulare) of the mandible.

The ptergoid (7) is a spade-shaped bone which projects downward from the ventral side of the skull. It articulates with the main body of the skull by means of a hollow, rounded process which articulates down over a knob-like projection on the occipital bone. Aside from the articulation with the occipital, the ptergoid articulates posteriorally with the quadrate and the squamosal.

The squamo-palatines (13) are long rather slender bones, flattened anteriorally. At about one-third of their length, from the



anterior end, they articulate dorsally with the parasphenoid and project down onto that bone for the remainder of their length. These projections are provided with teeth along the median line. Anteriorally the squamo-palatines articulate with the premaxillary and the maxillaries.

The parasphenoid (11) is the flattest and most extensive bone in the skull, and forms nearly the whole floor of the brain case, and at the same time the roof of the mouth. It is nearly the shape of a parallelogram with rounded corners, but it is a little broader in the optic region and becomes somewhat narrowed anteriorally. It

has no especial markings or features other than the impressions made by the bones which come in contact with it. On its ventral surface are two long narrow impressions left by the squamo-palatines.

The sphenethnoids (12) are the bones which serve as walls to hold apart the dorsal and ventral surfaces of the skull. They are rather long bones, about three-fourths as long as the parasphenoid. They articulate posteriorally with the occipitals, their dorsal edge articulates with the frontals and parietals, their ventral edge with the parasphenoid. Anteriorally they bound a portion of the openings into the occipital fossae.

The mandibles of *Notothalamus torosus* are each composed of two bones, the dentary and the articulare.

The dentary (14) is that part of the mandible which bears the teeth. It is a long slender, curved bone, articulating anteriorally with the other dentary, and widening out posteriorally to articulate with the articulare.

The articulare (15) is that part of the mandible which diverges posteriorally to form a rounded knob which fits into the articular socket of the quadrate. Anteriorally, on the median side it fits down into the dentary bone.

A New Aphis on California Sage

APHIS HILTONI n. sp.

(Figure 1)

By E. O. Essig, Division of Entomology
University of California

Apterous Viviparous Female.—

(Figure 1, A). Length 1.3 mm., width of abdomen 0.9 mm. Prevailing color pale green, the dorsum partially covered with a fine white powdery wax which is arranged in minute pore-like or mosaic rings. The areas not so covered appear dark in the illustration. There are numerous black pigmentations dorsally and laterally on the epidermis of the mounted specimens. The cornicles, cauda and anal plate; all of the legs excepting the basal three-fourths of the tibiae; and antennal articles, VI, V, II, I and the tip of IV are black or dusky. The remainder of the antennae and tibiae are yellow. The rostrum extends slightly beyond the base of the abdomen. The antennae are shorter than the body, the relative lengths of the articles being:

I. 0.065 mm., II. 0.055 mm., III. 0.227 mm., IV. 0.167 mm., V. 0.155 mm., VI. 0.280 mm., (base 0.130 mm., spur 0.150 mm.), total length 0.949 mm. There are the usual sensoria on articles V. and VI. The prothoracic tubercle is well pronounced. There is also a well defined pair of anterior and a pair of posterior abdominal tubercles (Figure 1, A. tub. i, ii, iii). The tarsi are small and one-third as long as the cornicles. (Figure 1, At.). The cornicles are black, cylindrical and somewhat tapered towards the tip, straight, slightly imbricated; 0.37 mm. long, and 0.06 mm. wide at the base. The cauda and anal plate are black (Figure 1, A. cauda).

Winged Viviparous Female.—

Length 1.20 mm., width of abdomen 0.56 mm. Prevailing color black with abdomen and legs dusky yellow. The dorsum may also be partially covered with a fine white powdery wax. The antennae (Figure 1.W. ant) are dusky to black throughout, the length of the different articles: I. 0.070 mm., II. 0.050 mm., III. 0.200 mm., IV. 0.155 mm., V. 0.153 mm., VI. 0.280 mm. (base 0.125 mm., spur 0.155 mm.), total length 0.908 mm. Article III usually has four or five large circular sensoria along the lower side, but there are sometimes six. The usual sensoria occur on V and VI. The rostrum reaches to the second abdominal segment. The prothoracic and abdominal tubercles are much like those in the apterous form and are illustrated in Figure 1, W. tub. The wings (Figure 1, W.) are normal in venation as illustrated. The lengths are:

primary 2 mm., secondary 1.2 mm. The cornicles are black, imbicated, cylindrical, somewhat larger near the base, the outer margin straight, the inner margin as illustrated (Figure 1, W. corn.). The length 0.10 mm., greatest width 0.05 mm. The cauda and anal plate are black and as illustrated (Figure 1, W. cauda).

RELATIONSHIP—This species has been carefully checked with *Aphis reticulata* Wilson, *A. oregonensis* Wilson, *A. hermistonii* Wilson, *A. tridentatae* Wilson, *A frigidae* Oestlund, and *Aphis artemiscola* Williams occurring in Oregon on *Artemisia tridentata,* and does not agree with any of them or other closely related species.

HOST—The species occurs in dense colonies on the apical twigs of old man or California sage, *Artemisia californica* Less.

LOCALITY—In Laguna Canyon one-half mile above Laguna Beach, California.

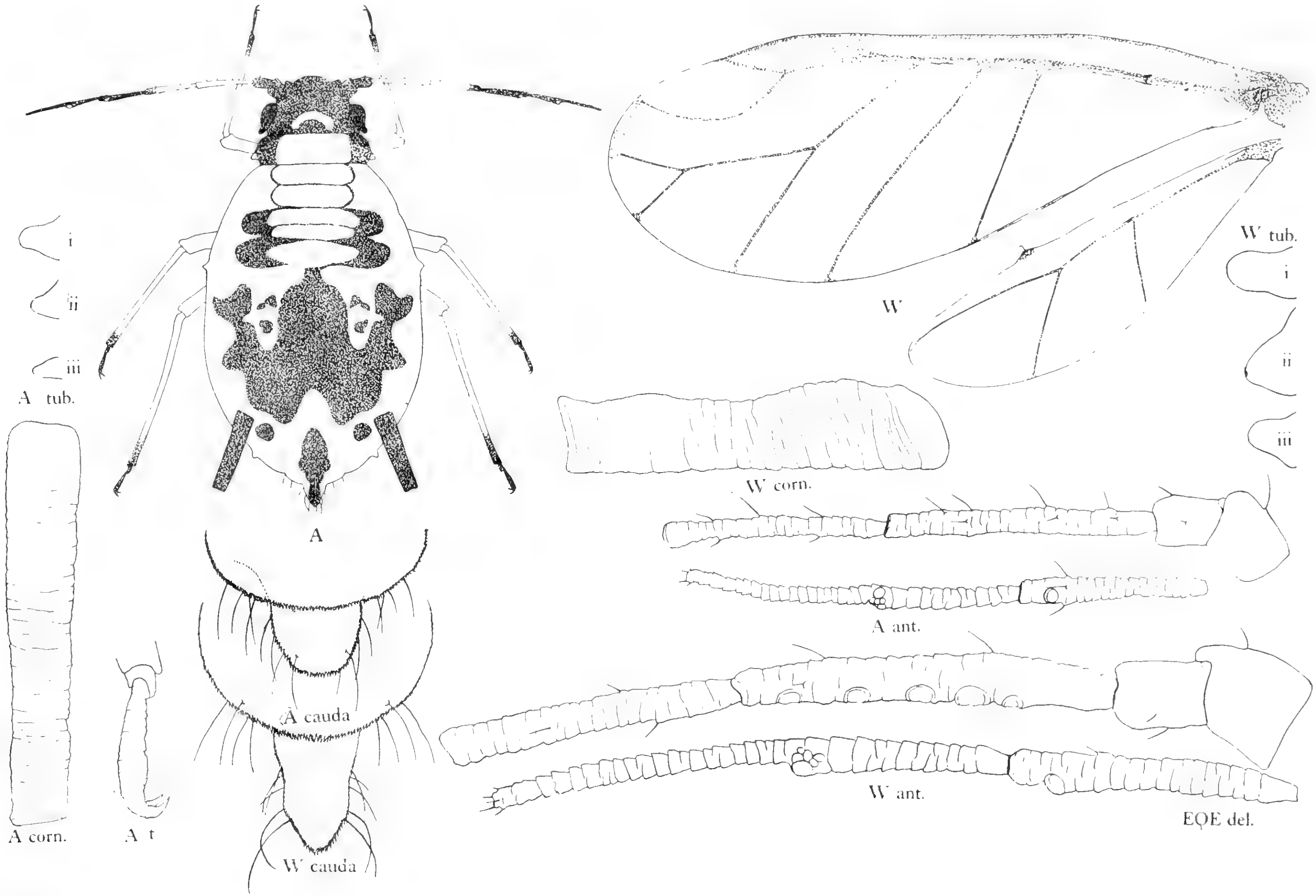
DATE OF COLLECTION—July 13, 1921.

COTYPES—The above description was made from a series of cotypes consisting of ten slides and over one hundred mounted individuals. The cotypes are in the author's collection.

The species is named after Dr. Wm. A. Hilton, Professor of Zoology, Pomona College, under whose supervision, inspiration and energy a most wonderful type of biological instruction is being given each summer at the Laguna Beach Laboratory.

Figure 1.—*Aphis hiltoni* n. sp.

A. Apterous viviparous female; A. tub., body tubercles of apterous female; i, prothoracic; ii, front abdominal; iii, posterior abdominal; A. corn., apterous cornicle; A., cauda, apterous cauda and anal plate; At. t., apterous tarsus; A. ant., apterous antenna; W, wings; W. ant., antenna of winged female; W. corn., cornicle of winged female; W. cauda, cauda and anal plate of winged female; W. tub., body tubercles of winged female; i, prothoracic; ii, front abdominal; iii, posterior abdominal.


A
A tub.
i
ii
iii
A corn.
A t
A cauda
W cauda
W
W tub.
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A ant.
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X. Phoronida and Actinotrochia

Wright in 1856 described the first species of *Phoronis.* Dyster, 1858, suggests two oesophageal ganglia. He found that the creatures were not particularly sensitive to light. I have a reference to a paper by Kowalevsky, 1861, on the anatomy and development of *Phoronis,* but as I have not seen it or a review of it I do not know how much the nervous system is considered.

Caldwell's publication of 1883 is the next paper of importance. He describes the nerve processes in connection with the ectoderm; both fibers and ganglion cells occur in the ectoderm. There are concentrations of the nervous tissue about the mouth to form a post-oral nerve ring; the anus is outside of this. The ring forms a line along the base of the tentacles formed like a horse shoe. In front of the ring is a pair of sense organs, the ciliated pits in the concavity of the lophophore on either side of the anus. There is an epithelium here with sense cells, ganglion cells and nerve fibers. The nervous system is further continued on the left side from the dorsal part as a cord or strand just outside the basement membrane.

McIntosh, 1888, in *P. buskii* describes a similar epidermal system concentrated about the mouth to form a post-oral nerve ring with the anus outside. The ring follows the line along the base of the tentacles and to the "ciliated pits" or concavity of the lophophore on either side of the anus. The nervous system has sense cells and ganglion cells and nerve fibers. On the left side is a cord through the body. The left longitudinal nerve tube or tubes of Caldwell is not described.

Andrews, 1890, in a new species describes the "glandular pit" of the lopophore and a large "nerve rod" on the left side, solid and surrounded by epidermal cells. It seems to have a fibrillated or possibly only a coagulated structure. The rod extends through a considerable distance and ends in a peculiar ring of epidermal nerve substance about the mouth. At this region there are two symmetrically placed nerve rods but the right is short.

Benham, 1889, finds the nervous system immediately below the epidermis as Caldwell was first to observe. Passing aborally from the lopophore ridge the basement membrane is seen to separate from the epidermis by a narrow ground substance not readily stained. In this granular substance are a few rounded nuclei belonging to small nerve cells. Fibers are also found coming from the epithelial cells of the surface. This nerve band follows the ridge of the lophophore passing around on the oral side and curves at the side of the nephridial ridges following the spiral course of the lophophore. It always keeps along the outer edge of the tentacles. From this band nerve tissue goes to each tentacle passing along its inner surface. A nerve goes to each nephridium and a nerve layer to the epistome, this being the only dorsal part of the nervous

system. There are no concentrations any place to form a ganglion; the chief nervous system lies ventrally. Two longitudinal nerve tubes or nerve bands are described running the length of the body. The nerve strands may give the appearance of tubes due to shrinkage; epithelial cells seem to compose it and the tissue does not look like nervous tissue. These longitudinal tubes or nerves may be some sort of sense organ.

Cori, 1890, adds nothing to the general knowledge of the nervous system.

Torrey, 1911, in *P. pacifica* gives a partial description of the nervous system as like that of *P. architecta* with the exception that "The two longitudinal cords which are of exceedingly unequal length, instead of continuing in the nerve ring of the lopophore, are continuous across the median line at the level of the median mass of ganglion cells. The loop thus formed is closely applied to the latter and touches the lophophore nerve on each side of the rectum, apparently without fusing at either point." I have found no such condition in several good series of well stained *Phoronis pacifica.* Either this was an individual difference or Torrey's material was poorly fixed.

Schultz, 1903, discusses the regeneration of the central nervous system.

De Selys-Longchamps, 1907, described the circular nerve ring and ganglion and the lateral nerve of Caldwell on the left.

Pixell, 1912, discusses two new species of Phoronida.

In *Phoronis vancouverensis,* there is the usual ring of nervous tissue at the base of the lophophore; from it five nerves continue up the tentacles. Across the dorsal surface in front of the anus is a large ganglionic mass composed of fibers and cells with large nuclei. This tissue is everywhere in intimate relation with the inner ends of the epithelial cells. In some sections two small lateral nerve cords ran along the right and left sides of the body close to the point of attachment of the lateral mesenteries and projected into the basement membrane. He describes these as, "punctated tissue." They are very short. Nervous tissue was found in the center of the pit at the proximal end of the body and also along the alimentary canal on the outer side of the epithelium especially marked in the region of the oesophagus opposite the nerve ring. Gilchrist, so he says, suggests this patch as an organ of taste.

Phoronapsis hamesi has a similar condition of the nerve ring but the ring is narrower and more elongated than in *Phoronis.* A conspicuous nerve cord extends down the left side. In the nephridial region it is separated from the epithelium and embedded in the basement membrane; after passing internally to the nephridial duct it turns outwards and rejoins the epithelium a little to the oral side of the lateral mesentery. From here it extends as a con-

spicuous cord in contact with the epithelium and projecting slightly into the basement membrane. The center is of a clear substance and about this center are nerve cells.

Harmer, 1917, in *Phoronis ovalis* gives the position of the nerve ring which he shows thickened on the dorsal side.

I have had some opportunity to study *P. pacifica* and a species of *Phoronapsis*. It is quite important in studying the serial sections of this group that rather perfect preparations be available, a condition not altogether easy, as sand often interferes with good sections. However a number of perfect preparations were obtained.

In general I found the nervous system much as already indicated by the many of the others. In *P. pacifica* I found central nervous system to have its chief concentration a little below the

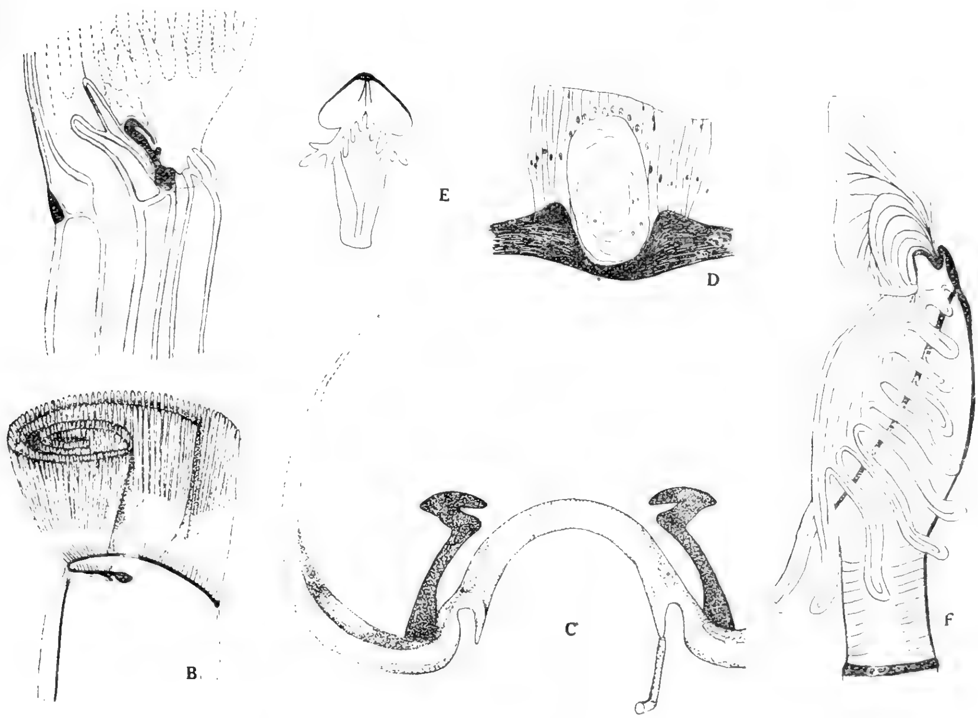

Fig. 21. A. Section showing position of nervous system of *Phoronis* after Schneider. B. Nervous system in *Phoronis* after Schneider. C. Diagram of a reconstruction of the nervous system of *Phoronis* showing longitudinal nerve cord on the right. Not all of the nervous system going to the tentacles is shown at the left. D. Section of nerve cord with epithelial cells on the outer surface and basement membrane in dark below. E. Actinotrocha larva showing the nervous system after Inedia. F. Diplochorda, after Masterman.

level of the anal opening and the nephridial tubules. This thickest portion of the nervous system directly continues with the epithelium of the surface of the body and is dorsal to the anal papilla in the depression caused by the anal prominence; from here the thickening passes toward the tentacles sending fibers to the lophophore and the tentacles. The lophophore depression on each side marks off the chief thickening of the nervous system. This central part, although continuous with the epithelium is made up of a distinct mass of fibers and cells. At this point three chief centers of cells are found among the fibers while out laterally strands run to the lophophore depressions and out to the tentacles. There is quite a mass of fibers and cells in the region of the lophophoral depression. Running out vertrally on the left side just medial to the lophophoral depression and between it and the left nephridium is the clear cord of unknown function noticed first by Caldwell. This cord surrounded partly by cells comes to run farther ventrally until it passes through the basement membrane of the body-wall and comes to lie just under the epithelium. This end does not seem to be of nervous tissue, although it is connected with the central part of the nervous system.

If I understand Torrey's description aright his material must have been too poorly fixed to show the relationship of the nervous system for in well preserved specimens the cerebral nervous system is continuous laterally with the lophophoral organs as well as with any lateral or longitudinal extensions of the nervous system. My observations both on *Phoronis* and *Phoronapsis* agree closely with those of Pixell. In *Phoronapsis* the central nervous system seems more elongated, as Pixell found.

With the exception of the central part of the nervous system the nerve cells are not clearly different from the epithelial cells, but careful study shows at the bases of the cells as well as farther down, nerve cells with their fibers directed into the basal mass of fibers. In the epithelium are bipolar cells, some of which may be sensory, although many of the prominent strands are those of supportive cells.

ACTINOTROCHA.

It seems best to consider the larval stage of *Phoronis* briefly at this place. Schneider, 1862, in his discussion of the development of *Actinotrocha* does not consider the nervous system. Caldwell has the first work of importance but his account, according to MacBride, implies that the apical plate and adjacent ganglion of the larva are lost, and the cerebral ganglion of the adult must be a new structure. But in every trochophore so far studied the apical plate with its ganglion forms the material which persists to the adult condition.

Masterman's paper of 1898 is a very important one. He mentions Wagner, '47, as the first to describe the nervous system. Masterman describes a central ventricular ganglion in the mid-dorsal line at the base of the prae-oral lobe, composed of ganglion cells and fibers. The ganglion is a proliferation of the inner cells of the epiblast. Nerve tracts radiate in almost every direction.

The nervous system may be summarized as follows:

1. Central ganglion in front collar region and between this and the prae-oral lobe. The epiblast in front is depressed to form a neuropore.

2. A ring about the posterior part of the collar is continued dorsally and ventrally giving off fine double groups of nerve tracts to the anal end of the body.

3. Groups of fine nerve tracts continued dorsally along the trunk from the anterior end of the collar.

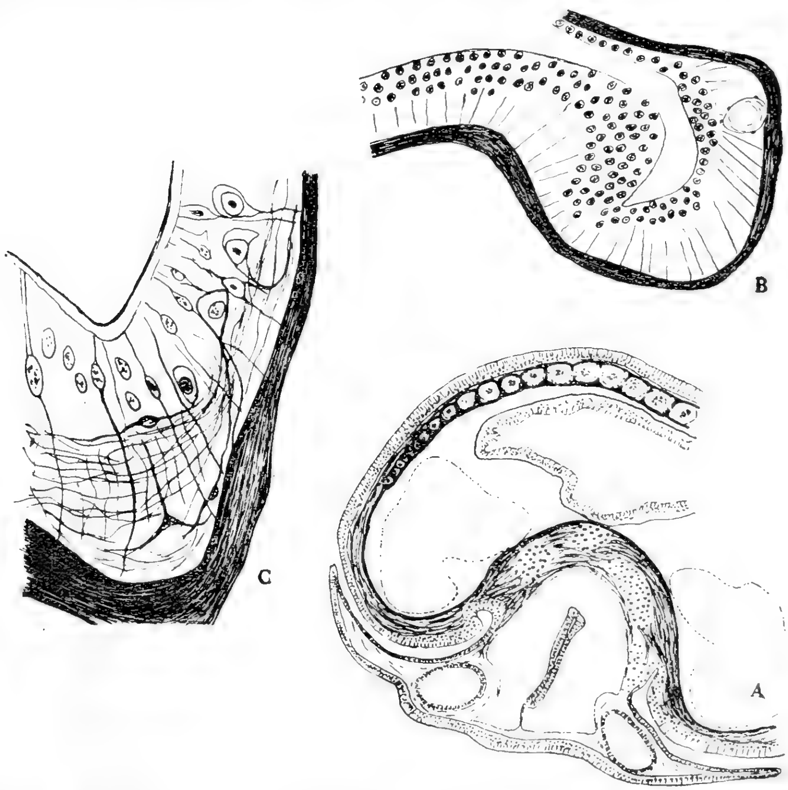

Fig. 22. A. Section through body and central nervous system of *Phoronis*. B. Small portion of lopophore showing depression. C. Small portion of the nervous system of *Phoronis* enlarged to show nerve cells.

4. A ring about the anal end of the trunk into which dorsal and ventral tracts lead.

5. A ring about edge of prae-oral lobe, joined at each side to the ganglion and in median front region by three main tracts running in mid-dorsal line.

6. A diffuse plexus of fibers at the base of all the epiblastic layer, including fibers of ventral collar region, which pass forward and dorsally to meet the ganglion.

Ineda, 1901, found no collar, nerve ring or dorsal or ventral commissure in the larva. He also failed to make out presence of the peri-anal ring. If present it is represented by a small number of parallel fibers. The main nerves were three in number close to each other and parallel along the mid-dorsal line of the trunk but confined to only a few sections posterior to the first pair of tentacles. There was found however a very complex and beautiful system of nerve fibers seen on the prae-oral lobe. Fibers are very numerous and fine and radiate from the ganglion on all sides towards the free margin of the prae-oral lobe. In the median line and anterior to the ganglion fibers are three long parallel strands on which the apical sensory spot is situated, not far from the ganglion. After passing through the sensory spot strands fray out into fine fibers which continue to the free margin of the prae-oral lobe. Fibers from the ganglion do not show a regular radial arrangement, but arise from the lateral edge of the ganglion and soon take an anterior direction. Sometimes near the ganglion there is an anastomosis of fibers, but probably more apparent than real. There are nerve endings in the prae-oral ciliated belt. There is probably an incomplete development of nerve elements in the collar and trunk region. He finds no neuropore and believes that Masterman's structure is due to contraction.

De Selys-Longchamps, 1902, gives a rather complete description of the nervous system. The central ganglion is a dorsal expansion of the epidermis with fibrillar substance below the surface. The depression which Masterman calls neuropore is not such a structure. There are three cords of the nervous system, the median is most developed. The apical organs are organs of sense.

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The Occurrence of Polygordius Adult at Laguna Beach

William A. Hilton

For a number of years now we have taken *Branchiostoma* just off shore in rather coarse sand, but it was not until the summer of 1920 that we began to look for archiannelids. A few doubtful specimens were obtained from sea weeds but nothing that we could be sure were the animals sought. We never thought to search the sand in which *Branchiostoma* was taken until after reading in the monograph on *Polygordius* how the creatures were obtained near Naples. With the hint that these animals were sometimes associated we examined with great care some hundreds of pounds of coarse sand in which some few *Branchiostoma* had been found and from this two specimens were obtained, one dead and one living. These were without question of the genus *Polygordius* although to make the matter more certain sections were made. Although the genus is certain, the species remains undetermined because the caudal ends of the animals were not perfect.

The living specimen was *very* active. At first it was taken to be a rather long round worm but the characteristic antennae at the head region caused it to receive more attention.

So far as I can tell, this is the first record of the *adult* of *Poylgordius* being found in North America in its natural environment at least, for some have been reared from the larval forms at Woods Hole.

(Contribution from the Zological Laboratory of Pomona College.)

Insect Notes from Laguna Beach, California

By E. O. Essig, Division of Entomology
University of California

The following notes were made during the Summer Session at the Pomona College Marine Laboratory, Laguna Beach and vicinity during June and July, 1921.

ORTHOPTERA[1]

Two earwigs, *Anisolabis annulipes* Lucas and *A. maritima* Brun., were commonly taken in the canyons in damp places under stones, logs and in wet leaves. The former occured under stones close to the creeks.

The cockroach, *Arenivaga* (*Homologamia*) *erratica* (Rehn), was taken under a large stone. The specimen taken was apparently full grown and a wingless male. A winged female was also collected.

The mantids,*Stagmomantis californica* R & H and *Litaneutria obscura* Scudd., were both taken on the hills near the ocean beach during July 1921.

The common tree cricket in the Laguna Beach region proves to be *Oecanthus nigricornis* var. *argentinus* Sauss. A number of these were taken during July.

The red Jerusalem cricket, *Stenopelmatus fuscus* Hald., was taken in a rotten log in Niguel Canyon. The common species at Laguna Beach which regularly traverses the streets at night and may often be found in the morning, is *S. longispina* Brunner (Syn. *S. irregularis* Scudd.).

The large blue-winged grasshopper, *Leprus glaucipennis* Scudd., proved to be a match for the most active entomologists and eluded many a net. The species measures from 2 to 2½ inches long and the color matches perfectly the color of the soil on the hills, back from the ocean where it occurs. The blue under-wings easily characterizes it.

THYSANOPTERA

Western grass thrips, *Frankliniella* (*Euthrips*) *occidentalis* (Pergande)[2]. A pale yellowish-brown species was abundant in the heads of *Juncus xiphiodes* Meyer growing in fresh water at the mouths of the canyons near the ocean.

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[1] Determined by A. N. Caudell, Bureau of Entomology, U. S. Dept. of Agriculture.

[2] Determined by A. C. Morgan, Bureau of Entomology, U. S. Dept. Agriculture.

The Christmas berry thrips, *Trichothrips ilex* Moulton, occurs in all stages upon the tree malva, *Malvastrum fasciculatum* (Nutt.). The young are bright cardinal red with the head, antennae, dorsum of prothorax, legs, and last abdominal segment black. The adults are entirely black. The insects feed on the stems and undersides of the leaves and the brilliant red nymphs are often present in considerable numbers.

This species also attacks the Christmas berry, *Heteromeles arbutifolia* (Lindl.) and a variety *Trichothrips ilex dumosa* Moulton occurs in southern and central California on scrub oak, *Quercus dumosa* Nutt.

HEMIPTERA

The Crackling cicada, *Cacama crepitans* (Van Duzee).- One of the most interesting insects in the hill region is the crackling cicada, so-called from the various crackling sounds intermingled in the long sonorous buzzing or droning which is at times so deafening. When captured they make a terrific high-pitched noise. The adults may be observed resting near the tops of various shrubs, but appear to prefer the California sage, *Artemisia californica* Less.

The black scale, *Saissetia oleae* (Bern.), is abundant at Laguna Beach, having been dispersed far over the hills infesting many native plants including the California sage, *Artemisia californica* Less., willows (*Salix* spp.), and the lemonade or sour berry, *Rhus integrifolia* B. & H.

The Cabbage Bug, - *Murgantia histrionica* Hahn.- The native black phase of this species, described as *M. nigricans* by Cockerell, occurs in great numbers upon the wild mustard. *Brassica campestris* Linn., and more particularly upon the wild bladder-pod, *Isomeris arborea* Nutt., growing on the sea coast hills and in the valleys of Southern California. On the latter plant it overwinters and survives the dry years when the mustard fails to appear. The writer believes that the above form of the cabbage bug has long been a resident of Southern California where for ages it has subsisted upon the two plants listed and should be considered as a native insect.

The eggs are often heavily parasitized by a minute black encyrtid, *Ooencyrtus johnsoni* (Howard)[3]. Adults of this parasite were reared from eggs taken chiefly from the wild bladder-pod growing on the hills near the ocean from Balboa Beach to San Juan Capistrano. They issued in greatest numbers during the month of July.

[3] Determined by A. B. Gahan, Bureau of Entomology, U. S. Dept. of Agriculture.

DIPTERA[4]

The common kelp fly, *Fucellia rufitibia* Stem, was particularly abundant on decaying kelp along the beach during the summer. In some instances the flies completely cover the masses of seaweed and rise in clouds when disturbed. It would be interesting to know the larval habits of this species.

The lemur syrphid, *Baccha lemur* O. S., was reared in considerable numbers from *Erium lichtensioides* Ckll. on California sage, *Artemisia californica* Less., which was abundant in the Laguna Beach Canyon.

The small gray leucopis, *Leucopis griseola* Fall., was reared in immense numbers from the leaves of muskmelon vines which were severely infested with the melon aphis, *Aphis gossypii* Glover. The small larvae and pupae were abundant on the undersides of the leaves. That a large proportion of the muskmelon vines growing along the ocean between Laguna Beach and San Juan Capistrano, were not entirely destroyed, may be credited to the efficaceous work of the larvae of this fly. I have never seen a predaceous maggot so numerous.

LEPIDOPTERA

The Sycamore borer, *Synanthedon* (*Aegeria*) *mellinipennis* (Bdv.).[5]- The work of the larvae of this moth on the trunks of the Western Sycamore or plane tree, *Platanus racemosa* Nutt., is very characteristic, consisting of numerous tunnels in the inner bark and the expulsion of quantities of reddish-brown frass which collects in the crevices of the bark and around the bases of the trees, at once calling attention to the presence of the insect.

The infestations occured on large trees and was confined to the trunks from the ground to a distance of about six feet. Many of the trees were infested with great numbers of caterpillars, but no evidence of serious injury to the general health of any of the infested trees was noticeable. The moths mimic in color, size and flight the common yellow jacket, *Vespa germanica* Linn. Indeed so great was the resemblance that the moths hovering about the tree trunks were first thought to be yellow jackets until they alighted.

A single grove of western sycamore, comprising some fifty trees, in Niguel Canyon was the only one observed to be infested by this moth, although there were numerous other trees in the different canyons around Laguna Beach.

The western sycamore is apparently the native host of this species, which is recorded from California and Colorado, without previous host records.

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[4] Determined by J M. Aldrich, U. S. National Museum.

[5] Determined by August Busck, U. S. National Museum.

HYMENOPTERA

The Yellow and Black Mud-dauber, *Sceliphron servillii* Lepeletier.-This interesting dauber is common along all of the streams in the vicinity of Laguna Beach. The elongated mud cells about one inch long are built singly or placed side by side in series of from two to four and the whole covered with a continuous layer of mud completely obliterating the outlines of the individual cells. The cells were commonly placed on the undersides of large rocks or boulders in the near vicinity of the fresh water streams and often at the mouths of the canyons near the ocean. The nests were stored chiefly with yellow and brownish-gray crab spiders.

In the cells and attacking the larvae of the mud-daubers was often found the maggot of a tachina fly, which proved to be *Pachyaphthalmus floridensis* Townsend[6]. The adults of this most interesting fly escaped from the masonry cells by the expansion and retraction of an inflatable bladder-like organ in the front of the head (ptilinum?) which was used to moisten the mud and then scrape it away. Adults confined in glass vials were easily observed to continually endeavor to work their way through in this manner. Not all of the flies appeared to possess or to use such an organ, but whether or not this is a sexual characteristic was not determined.

The fire ant, *Solenopsis geminata* Fab., was perhaps the commonest ant in the vicinity of the laboratory. During July the ants were swarming from their ground nests in great numbers. The workers are small, entirely reddish or with small rounded black abdomens, the winged females are reddish throughout while the winged males are black.

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[6] Determined by J. M. Aldrich.

XI. Brachiopoda

Perhaps in no group of animals is our knowledge of the general arrangement of the nervous system in such an unsatisfactory condition. Various published accounts are not altogether in accord even when the same species is studied.

Owen, 1835, seems to be the first to detect the nervous system. He describes white filaments which traverse the visceral cavity and end in muscles.

Huxley, 1854, considers the nervous system to be a ring of nervous tissue about the oral opening.

Gratiolet, 1857, 1860, describes a considerable mass of ganglinic material encircling the oesophagus but reduced to a small ring on the upper side of the oesophagus.

Hancock, 1859, says that the nervous system is easily seen but not clearly defined. In one form studied five centers of nervous tissue were found about the oesophagus, three of which were large enough to be called chief ganglia. He did not find a pallial nerve described by Owen.

Van Bemmelen, 1883, has a more detailed account of the nervous system. According to this author there is a pair of infra-oesophageal ganglia and two true supra-oesphageal centers. From both, nerves run to the arms. The nerve centers are composed of very small ganglion cells and fibers; the peripheral nerves are composed of straight fibers.

Beyer, 1886, describes a commissural ring surrounding the oesophagus at its junction with the stomach, in *Lingula.* There are nerve centers in the ring as follows: one central, two dorso-lateral and two ventro-lateral, these last being the largest. All centers are below the ectoderm and the nerve cells communicate with the surface.

Blockmann, 1892-3, gives quite a complete picture of the distribution of the ganglia and chief branches. In his work the lateral ganglia are widely separated and little emphasis is given to any supra-oesophageal center.

Delage and Herouard, 1897, give quite an extensive account of the nervous system. In their general account they speak of a simpler nervous system presuming to some extent embryonic conditions of connection with the epidermis. There is a large peribuccal collar formed of two dorsal cerebral ganglia and a ventral ganglion much larger and a little bilobed, with a pair of fine connectives. From the cerebral ganglia nerves go to the arms. From the extremity of the connectives a pair of nerves run to the cirri. Nerves in the arms anastomose and form a plexus of fibrous cells just under the epidermis. The ventral ganglion gives off, at its posterior angle, a pair of dorsal pallial nerves which run to a corresponding

lobe of the mantle. From the anterior angle a ventral pallial nerve soon branches into two, one for the dorsal lobe of the mantle and one for the corresponding adductor muscles. It is probable that these nerves also go to the muscles and viscera. In the ventral region is a plexus formed by the ventral pallial nerves. In the mantle the pallial nerves form a plexus with ganglion cells.

There are no positive organs of sense; there are neither eyes nor otocysts. Probably the margins serve as organs of touch. The cirri are probably for tactile sense, possibly olfactory. They have a rich nerve plexus.

Stomach papillae Joubin, 1886-92, suggested as gustatory, and the terminal papillae of the mantle Sollas, 1887, believed had a tactile function.

In Ecardia, Delage and Herouard give a separate account. A single pair of ganglia are situated very low and at the external

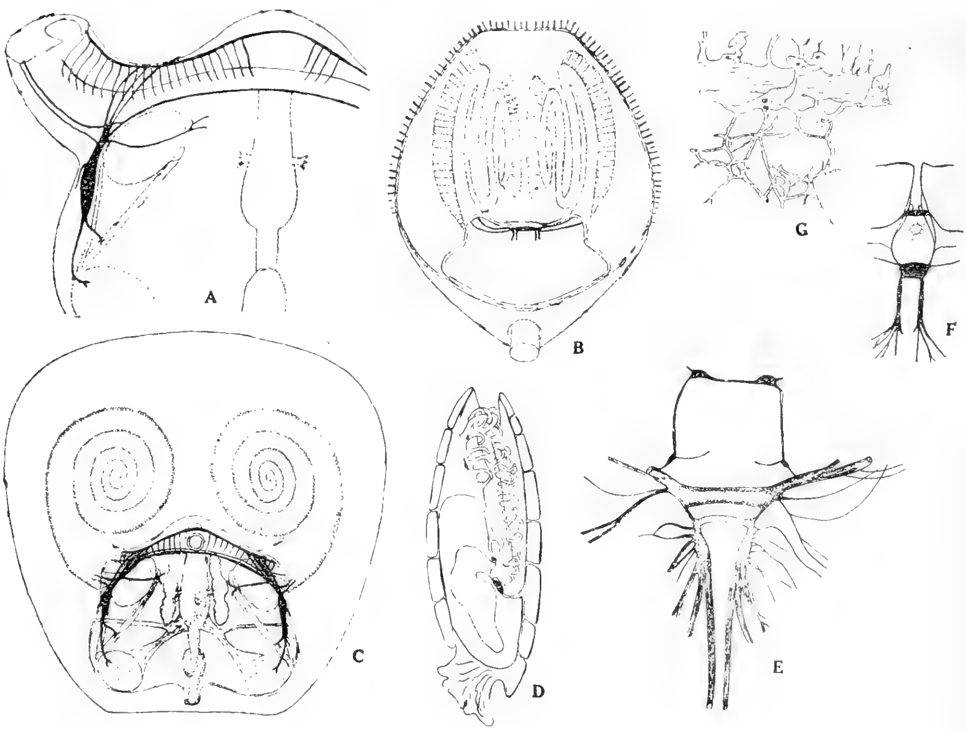

Fig. 23. Nervous System of Brachiopoda. A. Diagram of the nervous system from the ventral side showing the ganglion and chief nerves after Blochmann. Much modified. B. Diagram of the nervous system of a brachiopod, after Brammelen. C. Position of the nervous system shown in position. Diagrammatic. D. Diagram of *Lingula* showing ganglia in dark. E. General plan of the nervous system. F. Plan of the central nervous system. G. Nerve plexus.

border of the superior adductor muscles. A large ventral commissure unites the ganglia under the oesophagus. Each ganglion furnishes the following nerves: (1) to the adductor inferior muscle, a nerve with a little branch to the internal oblique muscle, (2) a nerve to the dorsal part of the mantle, (3) a nerve to the ventral part of the mantle, (4) a nerve to the arm, (5) branches which join with the ventral oesophageal commissure, (6) several nerves forming the dorsal nerve commissures. The dorsal commissure has nerves going to the cirri.

All nerves are under the skin. Cirri are probably organs of touch.

Heath, 1889, has found sensitive striae formed by high epithelial cells connected with the ganglion cells. These areas are along the middle line on the ventral side.

In spite of fragmentary and conflicting evidence the following seems clear as the nervous system of brachiopods:

A nerve ring surrounds the oesophagus; this is enlarged on the dorsal side in a small inconspicuous ganglion near the base of the lip. A larger suboesophageal ganglion is the thickening on ventral side. The ventral ganglion and perhaps the dorsal retain their primitive connections with the surface layer of the skin. Both ganglia give off a nerve each side to the arms and along the base of the tentacles and lips. The ventral ganglion also gives off nerves which supply the dorsal and ventral folds of the mantle and the muscles. In some cases the dorsal ganglion seems to be represented by a dorsal band only.

Sense organs are doubtful; the margins of mantle and cirri may have a tactile function and the epithelium on the surface of the ganglia have been suggested as olfactory areas.

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William A. Hilton, Editor

Claremont, California, U. S. A.

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